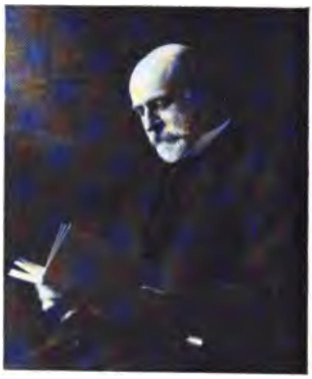

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OF THE

GEOLOGICAL SOCIETY OF DUBLIN.

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JOURNAL

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GEOLOGICAL SOCIETY OF DUBLIN.

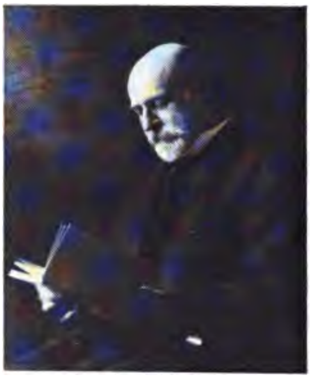
VOL. IV. 1848. PART I.

November 15th, 1848.—The session was, at the request of the Council of the Society, opened by the following Address from the President, Professor Oldham.

GENTLEMEN,

WE meet this evening, at the commencement of the eighteenth session of our Society, the first during which we assemble within the walls of our University; we meet under circumstances somewhat different from those under which we have hitherto assembled; with new prospects and with new hopes. It appeared, therefore, to your Council not undesirable that these circumstances should be briefly advèrted to; that this change in our condition and prospects should be noted, and that the ground of these hopes should be placed before you; and on me, as President, has the duty necessarily devolved.

The Geological Society of Dublin was, as many here are no doubt aware, established in the year 1831, for the express object, as stated in the constitution of the Society, "of investigating the structure of the earth, and more particularly of Ireland," and it at once took a high position among the scientific bodies in this city. We are not unwilling to believe that much of this rapid distinction



in the number of persons employed in those public departments more immediately engaged in the alleviation of the general distress, necessarily demanded increased and immediate accommodation; and your Council was therefore called upon, rather suddenly, to give up the rooms they occupied, those rooms being imperatively required for the public service. Gentlemen, having been at that time one of your Secretaries, I can therefore speak with some knowledge of the facts, and assure you that no proper exertions were spared by your President and Council to avert this injury, as far as in them lay; but I think I need only refer to the circumstances of the time to prove that this necessity for increased office accommodation did in reality exist on the part of the public departments. Finding it, therefore, vain to seek a continuance of those apartments, it became essential that your Council should determine what they would recommend to the Society to be done with the collections, and what steps should be adopted to secure the effective working of the Society for the future; and, after many and well matured deliberations, it was decided unanimously, that the recommendations submitted to a special meeting of the Society in December last, should be adopted. You are aware of the purport of those resolutions, and of their being unanimously confirmed by the Society at large. The officers of the Society were authorised, and proceeded to carry out these arrangements, and in consequence of them we now meet within the walls of the University, and under the sanction of its governing body, who most warmly seconded the views of your Council.

This change, however, gentlemen, appears to involve many more important considerations than a mere change of our abode, and it has not therefore been thought desirable to pass it over without notice.

At the time of the establishment of the Society, it was not until after much deliberation that it was determined to found a Museum in connexion with that body. Strong and influential opinions against the advisability of that course were forwarded to several of the members then anxiously engaged in framing the constitution of the Society—opinions derived from, and sanctioned by, the experience of similar associations in London and elsewhere. But after full consideration of all these reasons it was ultimately determined by the Society to commence a Museum, and I most fully concur in the

wisdom of that determination, under the circumstances. There was at that time in this city, no collection whatever available for the geological student—of simple minerals there did exist some collections, though not very usefully arranged for the student; but of geological, in its proper sense, there was literary none. Now, it was perfectly essential for the success of the Society, that such a collection should be accessible; and most wisely, therefore, did its members devote much of their attention to such an undertaking; and previously to its transfer to the University, a collection had been brought together and arranged, quite sufficient to enable the student of geology to acquire all the aid requisite in his studies. Again: more recently, when the applications of geology became of importance, the Society most wisely, (and most effectively too, considering the means at its disposal,) established a collection illustrative of those applications, and were thus the first, in this country, to found a Museum of economic geology.

But these necessities, I believe, would not have existed, were there other collections in this city available for these purposes; and had this been the case, it does appear to me that it would have been a misapplication of the funds of the Society, to have devoted any portion of them to the accumulation of specimens illustrative of such inquiries, when such collections were accessible elsewhere—and such, I believe, was also the feeling of your Council. It became, therefore, a special object for their consideration, whether, in the progress of time, circumstances had so changed, as to render any alteration in their arrangements desirable. Their experience had taught them practically the justice of the forewarnings they had received at their commencement, and they had felt that the reasons urged then against the establishment of a Museum were not without good foundation. Nor while they had been so anxiously devoting themselves to the spread of geological knowledge, had they been unmindful of the exertions made by other bodies in the same direction They hailed with sincere gratification the appointment in this University of a Professor of Geology in 1844, and the nomination to the chair of one who had so long and so sucessfully cultivated the science—they saw with peculiar pleasure the subsequent placing of the Museum here, under the charge of one of your Secretaries, knowing full well that the untiring zeal and unfailing exertions of its director would render that Museum worthy of the institution to

which it was attached, and of his own high and well earned reputation—and they perceived, and rejoiced too in the fact, that the collections of the Royal Dublin Society, under the charge of their able and deeply-read Professor, Dr, Scouler, were greatly increasing in extent and value—while, as regarded the applications of geology to practical purposes, it was with unmixed pleasure they watched the establishment by her Majesty's government, of a Museum of Practical Geology, under the immediate control of one of their own members, Sir Robert Kane, in which the objects which they had attempted with their limited means would be effectively and liberally carried out—while the extension of the Geological Survey of Ireland, in connexion with that of Great Britain, (thus securing an unity of principle in the execution of the work,) was an additional proof that public attention had been effectually aroused in this country to the value of such pursuits, and that however little they may have gained in a pecuniary point of view, still they had been instrumental in advancing the science, by increasing the number of those interested in it.

Carefully considering these facts, they thought it would be worse than useless for them to attempt, with their very limited resources, to fulfil duties which had been liberally undertaken by others with abundant means at their disposal; they, therefore, recommended that all your collections should be handed over to the University, satisfied that by the exertions already made by that body, a sufficient guarantee was afforded that these collections would be effectively and judiciously applied for the advancement of the science. They felt also in some degree honoured by having it in their power to make an acknowledgment of those important improvements; while at the same time they trusted it would prove an encouragement to their further extension.

In pursuance of this arrangement we meet this evening, gentlemen, within the walls of that University where most of us first imbibed our love of knowledge, where our most lasting associations were formed, and to which we look back as the source of our purest and highest enjoyments. We meet, too, under the roof of one who has so ably seconded and carried out the enlarged views of our first President; and who, through good report and evil report, has steadily advanced our views, and aided our intentions. We meet in a new abode, and under new auspices, with increased hopes

for the future, and increased pleasure in the retrospect of the past. It would be idle to attempt to conceal from ourselves the importance of such a change. To be thus admitted into connexion with the University, and to be acknowledged by the heads of that body, is an admission and acknowledgment not so much of us as a Society, as of the value and utility of the objects for the cultivation of which we are associated, and of those objects also in their highest and most important end, viz.—as a means and as a branch of education; and this consideration naturally suggests a few remarks on the real end and aim of our studies, and on the means which we can bring to bear on their improvement.

Probably the best, because the simplest, definition of geology, consists in the literal translation of the term itself, and we would thus define it—as the science of the earth, or the history of the earth, taking these words in their full and extended significations. It would be quite out of place here to detain you with any statement, however brief, of the successive phases through which this study has passed, or even to allude to the wild speculations of the earlier inquirers, in which geology was mixed up with the dreams of mythology, or fancies in cosmogony—speculations to which, however, we think too much blame has been attached, for from the then state of the collateral sciences it was impossible that any very sound advance could be made in geology. But there have been two prominent epochs in the history of our science, to which we may profitably allude for a few moments, inasmuch as the doctrines then propounded and received, have exerted, and continue to exert, an influence on the progress of our study—I allude to the times of Werner and Smith.

Long before Werner sent forth from Freiberg his system of geognosy, several valuable attempts at classification of the rocks of our earth had been made, and much information obtained; but it was reserved for him to propound a general theory regarding their distribution and classification, the principal features of which I need scarcely say, were the universal distribution of certain formations in a certain order, and the general aqueous origin of all rocks. It cannot be doubted that the classification adopted by him was a retrograde movement as far as scientific principles were concerned. His views were derived from a limited examination of a very limited district in Germany, and hastily and unphilosophically generalised

into a scheme asserted to be applicable to the world at large; and in this scheme he almost totally neglected all the information which had been already obtained as regarded fossils, Gifted, however, with a power of throwing a charm about his subject, which drew to him from every quarter eager and attentive pupils, investing those speculations with an ideal generality which they possessed not in fact; and in some degree masking the physical improbabilities of his hypothesis by his own peculiar acuteness of observation and power of methodising, he excited a similar earnestness in the students at Freiberg, and by their travels his views became rapidly spread, and maintained for a long time a supremacy among geologists. The notion of the aqueous origin of all rocks was at once and seriously contested, because there were few districts which did not afford proofs of the untenability of such an hypothesis; and the futility of trusting to mere mineralogical or lithological characters was also shown very soon; but to upset the most dangerous part of his scheme—that of the universality of the formations—was not so easy, for this required extended examinations in many districts, and in large areas. This notion, therefore, continued to exercise a most pernicious influence on the progress of the science—an influence, I regret to say, by no means exploded; for even in one of the most recent papers on descriptive geology published in Great Britain, we find the unconformability in area of two distinct groups of rocks (the old Red and Silurian) stated with all the prominence of italics, "as a most important conclusion," derived from extended examination—while in a proper view of the case it would have been indeed a most important conclusion, and one to be established only by careful examination, but never anticipated, were they really coextensive. It is unquestionable, that much of the errors which such a scheme contains, arise from the appearances presented in an isolated and very restricted area being considered representative of those which are universal; and it is not improbable also, that had circumstances placed Werner in a district of a different character, his scheme might have been very materially modified.

The epoch of Smith and Cuvier was also marked by a rapid accession of knowledge in our science; and by the proposition of sounder and more generally applicable views, and the observations of Smith, which established the fact of successive groups of organized beings being found in, and confined to, successive groups of

strata, excited great and deserved attention; but while tending most essentially to advance our knowledge on the subject, appear to me to have exerted an injurious influence also, from which we have not as yet been altogether freed.

The interest which such laws gave to to the examination of the fossiliferous rocks was such as to excite to the study geologists of every country. The value of their aid as auxiliary to the inquiries of the geologist became so apparent, that he forgot they were valuable only as explained by the naturalist. The advantage of a knowledge of the remains of animals and plants found in rocks, as elucidating the structure and mode of formation of these rocks, was so apparent, that every geologist devoted himself to ascertaining this knowledge, forgetting at the same time, that the only means he possessed of acquiring it, was by a study of similar creatures now existing, and many, anxious to describe the fossils which they found, were led to do so without due knowledge, and trusting to mere external form as a distinction.

A new name was given to this so called *new* science, and Palæontology was looked upon, described, and stated to be (and even still is by many) a branch of geology. We have on more occasions than one before now, endeavoured to show the fallacy of this notion. There is, there can be, no *new* science of fossil remains. The only means we possess of knowing any thing whatever regarding the structures and habits of creatures found fossil, is by a knowledge of the structures and habits of creatures still living. The study of the one is only an extension and an essential part of the study of the other; the objects, the laws, the methods of investigation, which regulate the one, are the same as those which should regulate the other. The examination of a plant, and the deduction of just inferences from that examination, is as much the duty of the botanist, and of him alone, whether that plant was gathered this morning, or whether we find its remains in the rocks formed countless ages since. The investigation of the skeleton of an animal, or of the shelly covering of a mollusc, belongs to the zoologist and comparative anatomist, and to him alone, altogether independently of the locality where they may have been found.

And if in existing nature it may be fairly demanded, that he who will undertake to describe the habits and structures of existing animals, should himself examine into those habits, and investigate

that structure, and if the conclusions of him who will be content to take such information from others, and seek not to ascertain the circumstances peculiar to the existence of such creatures, but depend on external form alone—if, I say, the conclusions of such a man are justly reckoned as of little authority, how infinitely less confidence should be placed on the conclusions of those who, in the much more difficult task of unravelling the habits and structures of those organisms, which we only know from their remains, rest contented with examining the collections of others, and, regardless altogether of the many causes which may have produced variation of form, hasten to accumulate distinctions, and to string together catalogues, which, thus prepared, serve no other end than to confuse our knowledge.

We would not be understood as in this arguing against the collection and study of these organic remains. Of their extreme value we are satisfied; nay, we believe, that that value has hitherto been much, very much underrated, or at least very *erroneously* estimated: but we would in the very strongest terms protest against the idea which appears to have possessed the minds of many labourers in this field, that such a study can be undertaken without, or independently of, existing organisms; and we would assert, that no benefit whatever can arise, so far as the true end and aim of geology is concerned, from such examinations and such classifications, even of thousands of different forms.

Be they ever so multiplied, facts when isolated are but of little value. We want the power and the means of colligating them. We see not the causes or the circumstances which have contributed to the production of the phenomena; and we cannot, therefore, trace, or even attempt to trace, the consequences which must result from them. It is in this, as in every other physical science—indeed in every branch of knowledge, the connexion of cause and effect, (to use the terms ordinarily employed,) this intimate and necessary dependance of every existing phenomenon on previous ones, that we seek to know and to discover; and the moment that we cease to be able to refer phenomena to their causes, that moment our knowledge of them becomes barren of its effects, and comparatively useless.

In the study of organic remains, therefore, we must never cease to search into the conditions of their existence, the effects which a

change in these conditions may have produced, the duration of that change, whether temporary or not; and therefore, whether on the return of similar conditions, similar forms of life have not also returned. We must seek to discover the laws which governed their distribution—the centres from which they have spread—their maximum period and maximum places of development; and thus, and thus alone, can we hope to eliminate from them the full measure of that information which they are capable of affording; and thus, and thus alone, will the study of palæontology have contributed its due share to the progress of our knowledge. While at the same time it must always be borne in mind, that in such inquiries the physical evidence of the condition of the area must never be made to yield to conclusions derived from organic investigations alone. The phenomena of life are too complicated and too numerous ever to be placed in fair competition with the laws of matter, and in all cases where there appears an opposition in their testimony, natural history must be led by physics and chemistry, and the right of precedence here, as elsewhere, be given to the exacter sciences.

It is always a difficult task to alter the general opinion on any subject, however erroneous such opinion may be. Facts, when discovered for the first time, either appear to the observer to harmonize with, or to be discordant from, those already known; they are looked upon either as confirmatory of known laws, or else as apparently contradicting them; and thus it would seem a necessary consequence of the state of our knowledge, that we seek to explain them by a reference to facts which we consider as more known, because of more frequent occurrence. The observers themselves are supposed to be, and probably are, the best qualified to suggest the best explanation; and this explanation, thus given, is received and held on their authority; phenomena being thus, on their first discovery, attributed to laws with which perhaps they have no true relation, and so attributed, simply because we are not acquainted with their correlative phenomena, these laws continue to be supposed applicable to the facts, at least by the majority of persons, long after their inapplicability may have been proved. The tenacity with which so called "popular prejudices" are held, may furnish a familiar proof of the difficulty of removing from the public mind ideas which usage has made a part of early tuition. And it is to some influence of this kind, it is certain, that we owe the very inju-

rious effect which the once popular notion propounded by Werner, of universal formations occurring in all countries in the same definite order, long exerted on the investigations of geologists, and even still continues to exert.

Smith and Cuvier had taught them a safer and a surer guide to a knowledge of the successive phenomena which had occurred on the earth's snrface, than the mere mineralogical examinations which Werner had inculcated, and yet they continued to apply to this new method of investigation the same laws, the same principles, which had been arbitrarily applied to the old one. The regularity and remarkable precision found by Smith to occur in the neighbourhood of Bath, and by Cuvier at Paris, was at once supposed, without the slightest investigation of the facts, to apply to all other districts; and the rocks of one country were sought to be *forced* into a parallelism or agreement with those of another. The truth announced—and cautiously announced—by Smith, that each group of beds was characterised by peculiar organic existences, not found in the beds above, nor in those below, was perfectly certain as regarded the district in which his examinations were carried on; but it ceased to be applicable—that is, applicable with the same distinctness or preeision—to any other district where the conditions had been different. Because it was found in one limited area that it might safely be asserted, that rocks which contained the same fossils were of the same age, this proposition, perfectly true in that limited sense, was at once, though most illogically, asserted in a general sense. It was forgotten to be considered, that the existence of organized beings inevitably depends on a variety of conditions favourable or unfavourable to their continued life, and that, therefore, that existence may in one district be continued through a much longer or shorter period, accordingly as those conditions may prove of longer or shorter duration. The discovery of the value of fossils having shown the uselessness of mineral character alone as a means of classification, the study or observation of that character was entirely neglected, although it should have been remembered, that in most cases it is the only satisfactory evidence we possess of the physical circumstances of the area under examination at the period of the formation of the rocks.

Gradually, however, new and sounder views have taken their ground, and instead of searching after and recording facts, however

unconnected, or collecting fossils, merely for the sake of adding uncouth names to some useless catalogue, and then boasting of how many hundred species have been noticed, a more philosophical spirit of induction now reigns. The laws which influence the distribution of animals and plants at the present day are searched into; the effects of permanent alterations in the medium in which they exist, the mode of accumulation of given materials under given forces, and the modifications to which these are subject—these are all eagerly investigated; and by the application of the line and the measure, results are obtained hitherto unequalled for their accuracy.

To this end the labours of British geologists have in no small degree contributed, and the establishment of the Geological Society of London, with the express view of investigating and collecting facts, regardless of theory, was one of the most important steps. Recalled from the absurd and monstrous speculations of olden times, to the safer and more valuable induction of facts, its members, ably seconded by the geologists of France and Germany, have brought together an immense mass of evidence, and accumulated a surprising amount of information—evidence testified by so many unconnected observers from various countries, and whose prejudices were all so varied, and so opposed, and so entirely uncontradicted by any conflicting testimony, that the truths thus established become irresistible, and preclude for ever the possibility of theorists reverting to speculations of the ridiculous nature of those of the early investigators.

I have, however, little doubt, that this exclusive devotion to the investigation of facts, has itself had an injurious effect of another kind, viz.—that it has repressed all saliency and originality of thought, and given a new, and even more pernicious, direction to that tendency to speculate which is inherent in our nature. The impossibility of pleading ignorance of the facts, or of running counter to them, has led to hasty generalizations of those facts; and these generalizations, necessarily put forward by men of high and original stamp of mind, as great and comprehensive truths, are received and retained by others. Much yet remains to be done in the removal of such difficulties, and much has yet to be unlearned. It appears to me a false and dangerous philosophy, though sanctioned by many of the high names in our science, which seeks to separate the observer from the investigator, to limit some to "the

bag and the hammer," while others presumptuously arrogate to themselves the sole authority to reason on the facts. The eye of the mind must be educated and exercised as well as the eye of sense. It is unquestionably true, that without this exercise of our reason in speculating on the causes of what is before us, we may see what others have seen before, and thus confirm knowledge already possessed—but if our observations are to tend in the slightest degree to advance the bounds of that knowledge, or correct its errors, we must be fully aware of the supposed causes of these phenomena, and make our observations the test of their truth. We must know why, as well as what, to observe.

And not the least advantage resulting from such studies, considered as a means of education, consists in such habits of observation, which they necessarily produce, together with their inevitable consequences, viz.—that they call into being, and provoke the exercise of a process of self-education, without which no man is well taught. For although in this, as in every other physical science, where the great means of acquiring knowledge is by observation—although, I say, much must be received on the authority of others, unless we would have the human mind remain stationary, and allow the accumulated stores of information of one man, or one generation of men, to be lost to another, still each for himself must go over these observations—each must trace the steps in the reasonings founded on them, and stamp those reasonings with the impress of his own individuality—each must observe, each must compare, each must discover for himself. And this process seems unavoidable, because it is to the mass of learners impossible to convey by the description of others, however lucid they may be, a clear conception of material forms and arrangements, which must be seen to be understood. The students are thus compelled to go to the great book of the world itself for their information, if they wish that information to be accurate; they are compelled, to use the graphic terms of Leonardo da Vinci, to be "the children of nature, and not her grandchildren," and to compare the records of others with that original record which she has every where placed before their eyes—the writings of men with "God's epistle to mankind," the earth. And we may safely affirm, that such habits of observation and comparison once produced will continue to be exercised. I think it is Savage Landor who eloquently says, that "nature

cometh not into the market-place with sound of trumpet to proclaim her truths." They must be sought after patiently and carefully. We must devote ourselves to her service, if we would be honoured by her confidence. "Rerum natura," says Seneca, "sacra sua non simul tradit * * * illa arcana non promiscue nec omnibus patent; reducta et in intimo sacrario clausa sunt." * * * "servat, quod ostendat revisentibus."*

In the prosecution of such inquiries also, new methods of reasoning and new modes of research are called into action. The questions to be solved are not of our own imagining, they are ready prepared to our hands. We cannot start by our own suppositions, and setting down definitions demonstrate identities as determined by a reference to such definitions. We must compare, we must determine resemblances by a reference to types. and establish a similarity in effects by their analogy to known results of known causes: and hence it is the cultivator of the natural sciences alone who fully appreciates the value of Newton's rule of philosophizing—"Effectuum naturalium ejusdem generis eædem sunt causæ"—because it is he alone whose mind is trained to the habitual determination of the question, as to whether the effects be really of the same kind—"*ejusdum generis*."

In this power of reasoning from analogy, in the necessity of estimating degrees of probability, and balancing varying amounts of evidence, and in the *educing* of the habits of thought consequent thereon, consists another and a very striking excellence of the natural history sciences as a branch of education. It was from a neglect of the proper exercise of such power, that the injurious effects of the doctrines propounded by Werner and Smith arose, to which we have already alluded.

And if in the study of the works of those authors, whose abilities have shed a lustre on the epochs in which they lived, we feel our emotions kindled, our imaginations delighted, our tastes matured, and our power over the complicated, but ever necessary, machinery of language increased—and if, by the higher sciences, our intellects are cultivated, and the dominion of our thoughts over the phenomena of the past and the future extended, while a spirit of rigorous exactitude is engendered, and an habitual demand for the demonstration

* Quest. Nat. vii. 30.

of a statement before it be admitted as a truth—and if in the investigation of ourselves as individuals, and as portions of the social system, we are led to habits of patient thought and important analysis, there yet remains, we are satisfied, a blank, which the natural history sciences alone are fully competent to fill; and we think that they will prove of essential service in the cause of education, by calling into active and continuous operation habits of thought, and educing powers of mind, for the exercise of which the other branches of an University education offer no sufficient field.

In thus alluding to the value which we believe inherent in the natural sciences as a branch or means of education we cannot but refer with extreme pleasure, to the recent establishment in the University of Cambridge of a Natural History Tripos, by which the honours assigned for the successful cultivation of these studies are placed on the same footing as those long awarded to classics and the exact sciences. This acknowledgment by such a body, and in such a way, of the utility of these studies, as a branch of education, cannot fail to operate most advantageously for their promotion.

But if this be really the case, and that our pursuits are truly of advantage, as parts of an educational system, it seems at once to suggest itself, that meeting now within the walls of a University, so long and so proudly pre-eminent for the freedom with which its educational advantages have been thrown open to all who desire to avail themselves of them, that we should view ourselves, even more than we have been wont to do, as an educational body, and as devoted as much to the improvement of others, as to the advancement of our own information. Let us not forget that we are all fellow-labourers in the great search after truth, fellow-pupils in the school of nature, fellow-students of that first book—the world; each ready and anxious to communicate to others any knowledge we may ourselves possess—each willing, and I trust, most anxious, to learn from others all that they can communicate. We may not, perhaps, be able to boast of many of those whom Bacon, in his philosophical fiction,* calls "merchants of light;" we cannot in Dublin, expect or anticipate that influx of communications on foreign geology which forms such a large proportion of the business of the Geological Society of London; but we have our "depredators," our "pioneers," our

* *Novis Atalantis*.—Bacon's Works, Vol. 4..

"lamps," and our "interpreters of nature." We can point to our Journal for the communications of many of these already, and we do hope for a continuance and increase of the number. And I cannot but express the hopes which have animated your Council, that we shall find a large accession of strength within these walls, and may justly anticipate a great increase in our knowledge on those higher points of speculative geology, to which the powers of the mathematician and physicist can alone be efficiently applied.

I must, however, be allowed a word of caution on such points, eagerly hoping, as I do, that the Society may soon congratulate itself on the high mathematical powers of some of its members being brought to bear on the investigation of its questions. I may be permitted to suggest, that in all such inquiries, the problem to be solved must be accurately ascertained, before its solution can be usefully given. I am led to allude to this, because geologists have been deprived of almost all the advantages which would have resulted from the contributions to physical geology, which mathematicians have already brought forward, by the simple but fundamental error, that the problem has been mistaken, and consequently the solution given, however accurate, is inapplicable to the purposes for which it was intended.

I have purposely avoided alluding to any of the *enjoyments* to be derived from such pursuits, although I keenly feel them myself, and believe the heart must be dead indeed to all such emotions which would not; but these enjoyments are not so much advantages resulting from the study of natural history, as inducements to that study; nor would I detain you with even an allusion to the many important ways in which our science addresses itself to the favour of the utilitarian, by the numerous practical results of great benefit which arise from its application. We have no fears that these practical applications of geology will ever be underrated or neglected in this University, which may claim the honour of being among the earliest to establish a distinct school for applied science, to which the chair of Geology is more immediately attached. And while we would on all occasions unite the endeavour to rise through successive steps of reasoning to the attainment of principles, with the limiting of these principles to particular operations— "ascendendo ad axiomata, descendendo ad opera"—we yet believe that the order in which these terms have been placed by the great author of inductive philosophy is the true one, and that these prin-

ciples must first be carefully ascertained, before they can be satisfactorily applied.

Much yet remains to be done, and done in so many ways that there is not one among us who cannot contribute. So extended is the circuit of our inquiries that every step we take, we are made to feel the necessity for the cordial aid and sympathy of others. To few individuals indeed is it given to possess that extent of knowledge which would enable them to range through all parts of our science; and even had this Society not existed, it would now be necessary to unite the efforts of many for the solution of our problems.

In looking back on our past career, if we have failed in ought let the failure be only a warning to avoid its cause, and overcome its difficulty: if we have succeeded, let our success be but an encouragement to further exertion. Remember the words of Demosthenes—

ὃ γάρ εστι χείριστον αὐτῶν ἐκ τοῦ παρεληλυθότος χρόνου, τοῦτο πρὸς τὰ μέλλοντα βέλτιστον ὑπάρχει. ἐπείτοι εἰ πανθ' ἃ προσῆκε πραττόντων, οὕτωσ εἶχεν' οὐδ' ἄν ἔλπις ἣν αὐτὰ βελτίω γενέσθαι[*]

But have we thus done our utmost? I fear not, and there is one mode in which many who perhaps may never have the opportunity of contributing original communications to our Society, may yet most materially aid the progress of others. I mean by additions to our library. And if a list of deficiencies, and of desirable additions, be laid before the Society, I will not think that our love has been so chilled, that there will not be found many who will be glad to have placed here some contribution which may link their name permanently with our progress.

Such, gentlemen, are our prospects for the coming session, and I hope most sincerely that at its close I shall be enabled to congratulate you on the fulfilment of these hopes, satisfied that any cause which may prevent such an issue must be one more general in its operations than as affecting us alone. So long since as 1831, the period of our first formation, the able professor of geology in Cambridge, speaking from the chair of the Geological Society of London, in words peculiarly applicable at present, and which seem almost prophetic, eloquently said—" Our studies have no part in those passions " by which mankind are held asunder—the boundaries of tribes and " nations are blotted out from our maps—the latest revolutions we

[*] Demos. Phill. 1.

"treat of, are anterior to the record of our race, and compared "with the monuments which we decipher, all the works of man's "hands vanish out of sight. If we have advanced with a vigorous "step for the last fifteen years, it has been during the peace of the "civilised world. The foundations on which we build are so "widely spread, that we require nothing less than a free range "through all the kingdoms of the earth—and if anything should "occur to cloud our prospects or retard our progress, it must be "accompanied by some moral plague which will desolate the face of "Europe. Against the visitation of such a calamity every man "whom I now address will join with me in heartfelt aspirations."

Permit me to add a word before concluding—to myself personally the meetings of the Geological Society have been sources of unmixed pleasure. I have been deeply interested at the time—I can recall the hours spent with you with still deeper enjoyment—the frank and cordial kindness I have experienced—the manly and ingenuous friendships I have formed, and the warm support I have invariably met with here, originating in the congeniality of common pursuits, have associated these meetings, in my mind at least, with all that is kindly in feeling and honourable in principle, and I would express my sincere hope, that I may be enabled to continue them in the same spirit. Controversies, no doubt, arise, and these are inseparable from the ever progressive character of the study; and perhaps there is no stronger proof of the vigorous and healthy manhood of our science than the fearless courage with which every statement is canvassed, and its evidence investigated, before it is allowed to take its place beside truths already established; yet these discussions, conducted as they have been with good feeling and mutual respect, snap no tie of friendship, and chill not the warmth of our intercourse. Let private differences here give way to the common good: no envious rivalry, but that generous and benevolent impulse of honourable emulation which prompts while it enables mutual assistance: no seeking after victory to the neglect of truth. Let our meetings continue to be distinguished by that freedom of discussion and freedom of intercourse—that unflinching expression of opinion, coupled with an equally unflinching kindliness of feeling, which have hitherto marked them; and I feel assured that they will prove to others, as they have done to myself, the source of warm personal attachments, and of healthy intellectual enjoyments.

November 15th, 1848.—"On Oldhamia, a new genus of Silurian fossils," by EDWARD FORBES, Esq., F.R.S.,F.L.S., Professor of Botany, King's College, London, and Palæontologist to the Geological Survey.

THE rarity of organic remains in the Cambrian, or oldest portion of the silurian strata, renders every addition to its fauna of great palæontological interest. The earliest fossils which have yet been discovered seem to be certain plant-like impressions, or casts discovered by Professor Oldham, at Bray-head, in Wicklow, and referred to by him in his communication to this Society in 1844. These bodies present the appearance in most specimens of a central filiform axis, with fasciculi of short radiating branches proceeding from its sides at regular intervals, or of bundles of such filiform rays without an axis. A close examination of them shows, that each branch is formed of a series of articulations, marking the positions of minute cells. The entire body presents a striking resemblance to the arrangement of parts in certain zoophytes, as in *Sertularia cupressina*, but are also consistent with those exhibited in many BRYOZOA, as in *Gemellaria* and *Cellaria*, an alliance more in accordance with the minute structure. I propose the name *Oldhamia* for these remarkable fossils, in honour of their discoverer, who has in them made us acquainted with what in all probability is a group of ascidian zoophytes, or rather compound tunicated molluscs, in stratified rocks of very early date, and has thus furnished an additional, and important fact in contradiction of the crude notion, that the earliest forms of animals are the most rudimentary.

"On the maps and sections of the County of Wicklow, published by the Geological Survey," by PROFESSOR OLDHAM, F.R.S., President of the Society, and Director of the Geological Survey of Ireland.

THE President explained in detail the geological map of the County of Wicklow, just published, entering on the classification of the rocks, their subdivisions and mineral character, and the method of constructing the sections; and detailed the principal points in which the researches of the officers of the Geological Survey had led to conclusions different from those previously published.

The details of these researches will be published in connexion with the Geological Survey of Ireland.

December 13th, 1848.—"Proposal for the general adoption of a new and uniform principle for laying down Geological Sections," by ROBERT MALLET, Esq. C.E.,M.R.I.A., &c.

ON examining the sections accompanying the many geological memoirs which now occupy this field of scientific literature, it is in vain that we look for any general or uniform principle upon which they have been laid down. In each case the author appears usually to have chosen some arbitrary line of section, for the most part across the line of strike, more or less obliquely, and giving his preference chiefly to the localities where the dips are largest and most precipitous, and the succession of strata the most complex and involved.

No reference to any particular azimuth has been deemed of the least import; nay more, it has seldom been deemed indispensable, that the line of section should be taken in one right line; and instances may be quoted in abundance of valuable memoirs by geologists of acknowledged standing, in which sections are projected out into one plane from a sinuous line, meandering over the country in various azimuths, whose directions have been chosen, wherever the author fancied would give the "most illustrative section" of his particular views; sometimes apparently through mere caprice, and most commonly more with reference to producing a striking, and gaudy display of colour and form, when attached to the wall of the Society or lecture-room, than with a view to present the best and fairest anatomy of the country considered as laid open to the eye.

The result is, that the existing sections, accompanying memoirs and reports, are of extremely limited value—of none, if the time and labour bestowed on their production be considered; and from their isolated existence, and arbitrary choice of direction, they admit of no inference whatever being drawn from them, as to the nature of any other section of the same country, at a distance, (whether parallel or across,) which may not be actually given. Nor, again, do the two or three sections as ordinarily given, enable any correct notion to be formed usually, as to the physical features of the country proposed to be described.

Thus for example, a section across Devonshire, taken nearly north and south, though giving a "highly illustrative" view, per-

haps, of the succession of strata would, alone, give a most erroneous notion of the physical character of the surface of that county, and no just indications of the class or degree of forces, that were concerned in its formation; but if in addition to this section, we examine another, taken from Landsend, say to Shepton-mallet, nearly at right angles to the former, the imagination becomes at once informed as to the true physical character of the three adjacent counties. We see at a glance, that the billowy contour, which the north and south section of Devon presents, is no true representation of the general character of the surface of the county. We look to the east and west section, and we find the sharp configuration of Cornwall gradually rounding into the more subdued hilly forms of Devon. And as we pass again into Somerset, we find formations of finer materials have impressed on its surface the peculiarity to which its scenery is due—rich flat alluvial valleys, level as seas, with long meandering hilly promontories projecting into them, and dividing them from each other, like forested continents, with waving seas of grain between. Yet north and south sections only, of each of the three counties, might be in physical contour very much alike.

To take a larger example. If we suppose a geologist of our day possessed of materials for a map of south America, he would probably choose for his "most illustrative" sections, one right along the chain of the Cordillera; and, perhaps, one or two more, chosen at random from this or that spot to some other, where the interval contained some point which he deemed needed enforcement or "illustration." His sections presenting a tremendous jumble of "anticlinals," and enormous disturbances, many of which, though close together in section, might have very little real connexion, and depending for very much below the surface line on inference, or too often on fancy, would convey no real or just notion of the physical surface of the continent; nor, indeed, convey any information whatever, beyond a confused and, perhaps, often erroneous statement of the succession of strata.

We shall recur, however, to this example, to show how different would be the result, if his sections were sufficient in number, and chosen in right directions.

The proper uses of geological sections may probably be comprised under three heads :—

1. To give the physical features of the country correctly; and,

thus, by addressing the educated imagination through the eye, to enable distinct ideas to be formed, as to the sort and degree of the forces concerned in its conformation and configuration.

2. To give a true picture of the succession of strata, and their true relations at distant points of surface; and as far in depth as may be *certainly inferred*, but no further.

3. To supply economic information, such as relates to coal measures and mines—mass and character of loose surface materials, and their relation to the subjacent rock, or those from which they may have been formed—quarries, agriculture, drainage, &c.

I presume it will not be contended that these conditions are even imperfectly fulfilled by the present order of geological sections. My object, then, is to propose a new method which shall fulfil these conditions and others besides, and which shall, if adopted generally by geologists, confer upon this part of our science, that uniformity and mathematical character, which its present and prospective positions, and its intimate relations with exact science already warrant.

My proposition is, that in future all geological sections, whether those belonging to private memoirs, or to great connected works, as in national surveys, should be laid down and published, under the following conditions, viz:—

1. That all geological sections shall be laid down in the planes of great circles, passing through lines, running due north and south, or due east and west; in other words, in latitude and in longitude.

2. That where *several* sections of a given district are capable of being had, (and they are always desirable) they shall be laid down parallel to each other, and at equal distances apart, whether running north and south, or east and west.

3. That all sections be plotted to equal horizontal and vertical scales, and all referred to the half-tide level, for datum line.

Where several such sections, both north and south, and east and west are laid down, they become in fact a sectio-planographic model of the district referred to. They may be conveniently laid down upon square-ruled paper, and may be drawn parallel to each other, with their respective base or datum lines, placed at distances equal to those of the planes of section, so that in most instances, the two sets of sections at right angles may mutually intersect

without confusion, and be laid down upon the same sheet, whose surface may also represent a skeleton map of the surface of the country, i.e., both sets of sections may be laid down on a copy of the uncoloured map.

From two such sets of parallel, normal sections, it will be obvious to any geometer, that any number of intermediate sections, in any required azimuths, may be inferred by well known methods, and laid down, as required, on separate sheets; and it is also plain, that instrumental means may be devised for mechanically transferring such intermediate sections, from the normal ones, and plotting them. So that when once the requisite number of north and south, and of east and west parallel sections are obtained, the whole district in question is laid open, and may be, as it were, further anatomized, in whatever directions, not only the original geological explorer may then deem "most illustrative," either of the country or of his particular views, but also in whatever directions future observers or critics may require, either for purposes of the field or of the closet, without again having to refer to anything beyond the normal sections and surface map.

I propose that north and south, and east and west, sections should collectively be called *normal sections;* and as very frequent reference will be requisite to the respective directions of sections in description, I would further briefly call every north and south section, or one in latitude, a *makrotome,* every east and west section or one in longitude, an *eurutome,* and every intermediate or inferred section in some other azimuth, a *mesotome.* Where an extended and connected survey of a kingdom is made, and such normal sections are adopted, their multiplication will render an easy mode of reference to any one, without tediously naming the places of its extremities, desirable. For this I propose, that the normal sections on the meridians of latitude and longitude, should be taken as origins, and called *principal normal sections;* and that those normal sections occurring between such be referred to by number. Thus, a principal normal section, east and west, on the meridian of longitude, passing through latitude, 52°, for example, will be the eurutome 52°, and all made parallel, and north of it, between it, and the eurutome of 53° will be designated as Eu. 1, Eu. 2, Eu. 3, &c., and in the same way for makrotomes; while the extremities and directions of mesotomes, may be at once indicated by referring

to the points of intersection of eurutomes and makrotomes, between which they are drawn as extremes, thus—

52° Eu. 1. × 7° Ma. 2. . . . . . . 53° Eu. 5 × 7° Ma. 20.

would express a section running diagonally through a portion of the south of Ireland, in a direction north-west and south-east, and whose position might be found upon any map.

For much smaller areas of survey, perhaps this notation might be a little modified.

Let me repeat here, however, that my proposed method comprises two distinct propositions, capable of being adopted separately or together. The one, *that all geological sections be made in great circles of latitude or longitude;* the other, *that many such equidistant parallel sections be given* as an important instrument of record in all cases.

It remains for me to add a few words in illustration of some of the advantages which I conceive geology must derive from the adoption of this method.

In glancing at a chart of the world, or at the surface of a terrestrial globe—however the eye at first be distracted by the utter irregularity of outline, the apparent confusion of surface and of all things thereon—we soon begin to perceive that all this complicated mass of seeming accident has nevertheless distinct relations to, and has been in fact formed by the great cosmical forces, acting upon, and in, the globe—that the globe itself has a perfect symmetry; that the great agencies of light, heat, electricity, magnetism, act symmetrically upon it, that is to say, with exact relations to revolution in, and plane of, orbit, and to its rotation and axis. Advancing one step we see the tides, winds, ocean-currents, climates, seasons, dependant upon the former, less apparently symmetrical, because involved mutually and in more multiplied conditions. And again advancing, we can perceive, although, we are as yet unable to trace fully, that the shapes, sizes, and bulk of continents and islands—the boundaries of land and sea—the lengths and directions of river courses—the existence of inland lakes and seas—of parched deserts—of rainless regions—of those of ever-dripping clouds—of thick-ribbed ice—of heat without a shadow—are still dependant upon these few great ruling symmetric forces; or in a word, that every form and phenomenon, which we are capable of observing upon our planet, whether

great or small—in time past or present—upon the earth's surface or below it—and however apparently paroxysmal or irregular—have reference in position, in extent, and in degree, to those great symmetric forces, which actuate the vast machine. If, then, geology aim at ultimately building up, from the ordination of these materials, a true cosmology, a real history of our planet—and to such unquestionably it tends, however feeble may have been our past approaches—it is plain that all our records of terrestrial conditions, all our surveys and sections, should properly keep in as close connection as possible with that *relation of symmetry, which is the condition of the forces upon which physical geology rests.*

Sections, therefore, in great circles of latitude and longitude, are *truly* normal sections, because *the only* sections which are really normal to the great ultimate powers of our earth—and as truly normal, whether only a yard in length, or girding the world.

When, hereafter, such sections shall be extended over vast spaces, it is difficult now to foresee the value and extent of the knowledge which they must convey through the eye; when they shall connect themselves over continents, with climate, temperature, and seasons, past and present, and through these, with all the relations of organic life—when they shall be sufficiently extended, to connect in one view, and enable the imagination to apprehend—which it must do before the reason can comprehend—the relations between the interior structure of our globe, with the forces acting upon its depths from without, and the structure and physical character of its crust, and the beings which inhabit it.

Let us recur to our example of South America, and assume sections, cutting it into parallel strips of a few miles wide, both north and south, and east and west. We already know enough to see with what interest we might observe in the makrotomes, the long prevailing swelling outline of the land—the great river courses—the deep depressions—the sudden uprearing of the serrated crests of the Andes; and in the eurutomes, as the eye traversed over them, from south to north, we should see the rocky land abruptly plunging into the oceans on either hand, but soon stretching out on the right into the elevated mighty table land of the Pampas, with the crests of the Cordillera, ramparting the Pacific, and the long sloping plains to the east that connect the Pampas with the Atlantic; such would be the first glance, but who shall set a limit to the amount of

physical information, which such a set of sections would convey, when the rocks below, in their relations of position, magnitude and nature were laid open to the eye, in direct connection with all the forces and conditions of the surface; what might we not gather at a look from such a picture?

Oneness and largeness of view are essentials to grasping the primal ideas of formative forces—the hypotheses, if not the theories, upon which geology depends. The want of these has at all times, but most strikingly in the epoch of Werner, retarded its progress. Of late a great advance has been made in the right direction by the publication of physical atlasses by Berghaus, Johnston, and others. These, however, do not meet the peculiar wants of geology, and with much desire to avoid that sanguine view which always follows a new thought, I cannot avoid the belief, that the extension of sections such as I now propose, would be found *an organon*, a machine of discovery in physical geology, such as the indeterminate calculus has been in its application to exact science.

Contoured maps have already been proposed; and in some places executed as aids to geological investigation. Without denying their utility, I cannot admit that they are any substitute for these sections; they give no connexion between the surface features and what is below; nor do they lead the mind through the eye to connect the formation, and configuration of the land, with the forces which have moulded, and which are acting upon it, and with its biological relations: for example, what information can a contoured geological map give of the relation at various points over a large area, between the nature and depth of loose superficial deposits, and the sort and positions of the rocky formations below, or of both, with the past and present forces which have ground down and distributed the former. But, again, contours can scarcely be extended beyond the land, yet it would be of great value that all geological sections should be produced as far as possible under the sea. How vast a proportion of the whole surface of our globe is hidden by the ocean; yet in it, and especially round our shores, the great and ceaseless elaboration goes on, by which new lands are formed, and the earth, which has "waxed old as doth a garment," is "changed as a vesture," and again fitted for the use of man. The mere outline of sea-bottom, if laid down according to the preceding plan, as far as soundings extend, would, in connexion

with the sectional geology of the adjacent land, and with the known tidal currents, give much new and valuable information; most so, if specimens of the sea-bottom dredged up at many known points were examined externally and chemically.

But one instance of such sea-bottom sections has met my eye. It is the chart of the German ocean given in Mr. Robert Stevenson's account of the Bell-rock Light-house, in which, with that intuition of symmetry, which belongs to the eye of the Engineer, he has made every section, in great circles of longitude; and, although the sections are not numerous, yet the chart conveys to the eye a clear notion of the aqueous forces that have conspired to produce the singular sea-bottom between the coasts of Scotland and Norway, England, Holland, and Denmark. In such sea sections, the half-tide level, of course, should become the datum, so that the sea surface should coincide in level with the base or datum line of the land sections.

Had this paper not already extended to too great length, I might proceed to show the value as economic instruments, which the mapping our own countries by such geological sections would give. Of what use, to coal-winning, quarrying, and mining, they would be —not only in opening to the eye the very bowels of the land, and laying bare the secret places of its treasures, but in showing the probable extents of subterraneous water sources; the directions of their outpourings and the best means of diverting them from the working below, or bringing them in springs and wells to the surface for use.

Of what value to the agriculturist in showing him the magazines of ancient rock, from which his soils have been transported—where these are fertile—where barren, and why; the direction and capability of local drainage, and its relations to the natural water-sheds of the land. But these and other such points I must leave to the sagacity of geologists, and conclude with but one more remark.

Actual models, geologically coloured, have been sometimes recommended as the best representations of districts.

To models belongs one defect, which they have in common with all geological maps. The actual surface of the land everywhere consists, partly of solid earth-fast rock—the skeleton, so to speak, of our mother earth; the other of masses of loose material, laying

scattered over it here and there—which, like clothing with flesh, rounds and smooths the outline of our landscape.

Now so far, no principle whatever appears to have been fixed by geologists, as to whether in any given map, they shall represent the subjacent rock formations only, over the whole surface, or the loose superficial deposits only, or how much of either; and, accordingly, most geological maps present a very puzzling mixture of loose *transported* materials, shown as the formation of the surface in one place, and fixed, or non-transported rock, at others. For example, if the actual surface materials be adopted, as those most proper to be mapped, and it is difficult to see any principle upon which any other choice has been made; then a geological map of Ireland would present little more than post tertiary gravels and peat; but its actual maps have partly shown these, and partly shown the rock below them, leaving both sides of the subject incomplete. Both should be shown, if possible, because both have intimate connexions, and are of scientific importance as well as of economic value; but neither map nor model can by possibility compass this —and while geologists would certainly make an advance towards a principle, by either giving us in their maps, the surface or the formative rock—either giving us the "rock or the rubble," and not sometimes the one, and sometimes the other; the greatest advance would be to construct our geological charts, so as to show both —and this condition, the system of parallel normal sections which I propose, can completely fulfil, as is obvious without further enlargement.

P.S.—Since this paper has been written, I have been favoured by a note from Professor Oldham, enclosing me a sheet of the Geological Survey of County Wicklow, upon which, in accordance with my suggestion made at our last meeting, (November 1848,) he has caused some normal sections to be drawn in. These, although further apart than they might have been, had there been more time for adding to their number, fully show the practicability and value of maps having both systems of normal sections laid down upon one sheet, and mutually intersecting. I cannot avoid congratulating my friend, Professor Oldham, upon thus being the first geologist to adopt, (with his usual zeal for improvement,) a system which I hope all geologists will accept, and extend the use of universally.

December 13th, 1848.—"On the Silurian fossils collected by the Geological Survey of Ireland, at Portrane, Co. of Dublin," by Edward Forbes, F.R.S., &c. Professor of Botany in King's College, London, and Palæontologist to the Geological Survey.

The author communicated to the Society last session his observations on the silurian fossils of the Chair of Kildare, and shewed how the beds in which they were found were of a lower silurian age, and the equivalents of the "Bala beds" in Wales. By this determination, a base line for the Irish silurian strata was obtained palæontologically, and a great step gained towards their comparison with similar beds in the sister country. Since that time, considerable collections have been made at Portrane, and an examination of them has confirmed their identity with the Kildare beds, and the conclusions formerly inferred concerning the age of the latter. The published lists of Portrane species, given in Mr. Griffith's synopsis, drawn up by Mr. M'Coy, includes sixteen forms, one-half of which are corals, and the remainder are brachiopoda. A provisional examination of the Survey collections has yielded at least as many as seventy-seven, amongst which are twenty-three trilobites, ten gasteropods, four lamellibranchiata, and twenty brachiopoda. Several of these are new, and some of them very remarkable; more than forty of them are identical with species from the Chair of Kildare, including many of the most characteristic, as *Illænus Bowmanni*, very plentiful; *Sphærexochus calvus*; Spirifer *biforatus, insularis*, and *monilifer*; *Leptæna, sericea, quinquecostata*, and *depressa*; *Naticopsis concinna*; *Turbo rupestris*; and *Orthoceras gregarium*. Some other remarkable species are identical with characteristic forms from the silurians of Tyrone. The Portrane beds are locally peculiar for the quantities of corals they contain, and for the presence of *Trinuclei* in their limestones. These local peculiarities are often striking in beds equivalent to the Bala limestones.

January 10th, 1849.—" On the Cuttings exposed on the line of the Dublin and Belfast Junction Railway, by GEORGE V. DU NOYER, Esq. Geological Survey of Ireland.

THE sections which this evening I have the honour to submit to the Society, at the request of Professor Oldham, our President, and Director of the Geological Survey of Ireland, represent portions of the line of railway extending from Drogheda to Newry, termed the Belfast Junction, and include a distance of about eleven miles, commencing at Dromiskin, and terminating near Jonesborough-road, about six miles north of Dundalk.

Before calling your attention to the most interesting part of this section, which occurs at Faughart, north of Dundalk, I must offer some brief remarks on the cuttings north of Dromiskin. Here we observe a bed of dark purple vesicular trap, variable in thickness, which appears to cut in a horizontal manner through the green, gritty, and silty slates of the old silurian system. The trap, besides containing large included masses of pure grey carbonate of lime, abounds with minerals—those most prevalent being quartz, calcedony, carbonate of lime in geodes, and cubical iron pyrites. The slates in junction with it are changed to a kind of porcelain, and otherwise rendered hard and splintery. Again, about one mile nearer Dundalk, we find a good example of the power possessed by the former drift action, whether it was water, mud, or ice, or all three combined, to move slightly large and extensive masses of slate from the surface of the subjacent and nearly vertical rock.

Passing Dundalk, we find a cutting of about five hundred feet beyond Forkhill-road, through the green gritty slates and red and green shales of the system alluded to; and here we observe three cutting dykes of dark bronzy purple, hornblendic and micaceous trap. The thickness of these dykes is consecutively five feet, one foot, and four feet. In two instances their strike corresponds with that of the slates. In the third example the dyke cuts obliquely through them at an angle of about five degrees.

These are the only facts worth recording in the district over which we have passed; and I shall now attempt to describe those singular cuttings at Faughart. At the old road to Newry these cuttings commence, and extend northwards for the distance of 2,150 feet. The section at first exposes old silurian green gritty slates, and

green and purple shales, which are all more or less contorted and confused for the distance of two hundred and fifteen feet, when a break occurs, and we get to hard greenish slates, observable for the distance of two hundred and twenty feet, having an average dip N.N.W., the direction of the rails being forty degrees E. of N. and W. of S. In the centre of this mass, and running through it, we find a dyke of fine-grained, dark-coloured trap, three feet thick, in places resting on the edges of the slates, at others on their uneven surfaces. On the west side of the cutting this trapdyke is traceable for the distance of eighty feet, with a strike N. and S., at a variable angle of inclination to the E. and W., the slates in contact with it having undergone a certain amount of hardening.

We find the green and red slates appearing in small patches north of this, for the distance of three hundred feet, and, before we lose them, they dip S. 80°, thus appearing to form a synclinal. I should remark, that where we lose the slates they become of a dark-red claret colour, and the exact spot where they disappear is not seen; they probably are cut off by a considerable fault. In the distance of a few yards we meet a singular bed or mass of light grey limestone nodular conglomerate, enclosed in dark-red purple friable shale, portions of which adhering to the nodules cause them externally to resemble it in colour. What this conglomerate is I am unable to say. The section on the railway affords no data to determine its position or name, and my examination did not extend to much of the surrounding country.

We can trace this mass for thirty feet, and above, and apparently resting on it at a low angle, are soft dark-red shales, and coarse-grained felspathic dark-red grits of what appears, from its lithological character, to be old red sandstone.

The succeeding one thousand feet of the section is occupied by this sandstone, which, throughout the entire distance, is traversed in every direction by large and small masses of trap of different ages, forming vertical cutting dykes as well as horizontal, and I think contemporaneous beds or flakes. As these are of much interest they merit a description in detail.

At Faughart Farm Road-Bridge, where the sandstone first appears dipping E. and S. of E., at a maximum angle of about twenty degrees, we observe interstratified with it a bed of dark purplish green and fine-grained splintery trap, six feet thick, resting on a

thin seam of brown earth. This, in connexion with the fact of the trap being dislocated by the same faults which displace the sandstone, disposes me to regard it as contemporaneous with the latter, and thus, in the following description, I venture to designate it by the term, "old trap bed."

Passing Faughart Bridge, and included in the short distance of one hundred and four feet, we observe seven distinct breaks in the sandstone, which likewise displace the included old trap bed; at two of these fractures there are small masses of recent intruded trap making their way through the more ancient trap bed as well as the sandstone; and on the east side of the cutting, some distance removed from it, one of these intrusions assumes the appearance of a dyke five feet in thickness.

The sandstone, with its associated bed of trap, is now undisturbed for the distance of one hundred and twenty-five feet, when they are both abruptly cut through by a large funnel-shaped cleft or hollow, forty feet wide at top, and filled with brown clay and rolled masses of grits and primary rocks. Along the south face of this cleft a large mass or dyke of recent trap has burst up, and, attacking the lower surface of the old trap, appears to have melted it. The recent mass, having cut through the older bed, assumes the form of a wedge, about ten feet thick at the base, and cuts diagonally upwards through the bedding of the sandstone, having, close to its junction with the upper surface of the old trap, sent off a horizontal sheet of trap, one foot thick, into and parallel with the bedding of the sandstone. Below this flake of trap, one bed of sandstone remains, one foot thick, and which rests immediately on the upper surface of the old trap bed.

At the north side of the cleft, the old trap again appears, having resting on it eight feet of sandstone, which is capped by a bed of trap, six feet thick, which, from its mineral structure, I am induced to regard as recent. At the distance of thirty-four feet from the north side of this cleft we observe a fault displacing the beds to the amount of four feet, and then we have a large trap dyke, six feet thick, cutting vertically through the old trap and sandstone—the former appearing at the bottom of the section, and extending northwards for the distance of about twenty feet, when it disappears. The cutting dyke to which I have just alluded, is compact, light grey, coarse-grained, and vesicular in the centre,

but quite spheroidal and ochreous at the walls. Its strike is N. and S., crossing the railway cutting obliquely. At an elevation of about twelve feet from the bottom of the section it traverses a horizontal bed of recent trap, of six feet in thickness, which appears to have forced its way into the bedding of the sandstone. To the south of this dyke, and on top of the section—that is, about twenty feet above the level of the rails—there is a portion of a second bed of recent trap also resting uniformly on the sandstone. It is not improbable that both the trap beds last noticed may have been given off by this cutting dyke.

At the distance of nearly two hundred feet north of this dyke a mass of trap has burst through the sandstone, which is here thick bedded, coarse-grained, and compact, and it sends off to the southward two beds—the lower averaging two feet in thickness, and one hundred and thirty feet in length, the upper something more than one foot thick and forty feet in length, both beds following the bedding of the rock, into which they have been intruded; while to the northward the same rent has given off a thin flake of trap, averaging but one foot in thickness, and running along the bedding of the sandstone for the distance of three hundred and twenty feet, accurately following the various contortions and curvatures of the beds. In one place on the east side of the rails this bed is observed to branch into two; and in one instance on the west side of the section a thin trap bed tapers to a fine point, presenting the appearance of a succession of spheroids lessening in size.

Tedious and, perhaps uninteresting as a description such as this may be, I feel sure that a visit to the place which I have described will never disappoint any geologist; and if he possess a proper share of enthusiasm he will linger with pleasure over the striking tableau of former volcanic action there presented to him; and to detail the wondrous story there told with such mysterious simplicity and eloquent silence will ever recall to him, as it does to me, the first impressions of the place, which must be those of wonder and delight.

I will conclude my description of the remaining portion of the railway cuttings under consideration, by observing, that beyond the red sandstone at Faughart, the section exposes a mass of green grits and slates contorted and fractured in a singular variety of ways, and in the short distance of four hundred feet cut through

by four dykes of trap, the largest of which is six feet thick. They are all simple dykes, and do not seem to be connected as at the Faughart cutting.

At the distance of one thousand two hundred feet northwards a large elvan of porphyritic granite occurs at the east side of the railway, and even through this a trap dyke has found its way. I regret not being able to offer a detailed description of this portion of the line, as it was quite concealed by debris. Certainly the locality under consideration is, *par excellence*, the region of trap dykes.

Beyond this, as we approach Claret Rock Hill, the cuttings had not been commenced during the month of May last; and as they were intended to be to the great depth of fifty-four feet through the slates, I have no doubt but that many curious trap dykes will be there discovered.

At Claret Rock Hill the excavations are through the granite, and here trap again appears, cutting through the former rock in lines agreeing to its jointing. In the distance of five hundred feet the trap spreads out through the granite in flakes, seams, and threads—in some instances moulding itself to the joints, at others cutting directly through the rock, independent of all fissures. Those cuttings terminate at the small stream which forms the boundary of the counties of Louth and Armagh; and the last object visible in them is a trap dyke, striking north and south, and five feet thick.

Near to Jonesborough road the cuttings are through granite, and close to the stream south of the same locality a mass of trap, from forty to fifty feet in thickness, appears in the granite, apparently affecting it so much at its junction as to cause the latter rock to decompose into a green friable mass for the distance of many yards north and south of the trap.

This paper was illustrated by the detailed sections prepared for the Geological Survey of Ireland, to a scale of forty feet to the inch.

"On the cuttings of the Belfast and Ballymena Railway," by JAMES M'ADAM, Esq., F.G.S., Lon.

The Belfast and Ballymena Railway being now finished, it may not be uninteresting to describe some of the phenomena presented to the geologist in the cuttings. None of the cuttings being very deep, there is not the variety of geological structure brought to view that might have been expected in a section wholly in the county of Antrim. However, some of the phenomena are very striking, and a description of them should be preserved by way of record.

On leaving Belfast the course of the railway is along the north side of Belfast Lough, and is upon an embankment until it reaches Macedon Point, where there is a cutting through variegated marle, containing gypsum, and a whyn dyke is also traversed; the dyke, like the rest in the county of Antrim, runs almost north and south, but it has a peculiarity in its being inclined, or with a sloping side, and not perpendicular. The marle contains various thin subordinate beds of sand; but it is worth mentioning, as a botanical fact, that the year after the cutting was made in the marle, the sides became covered with the common weed, the Sinapis arvensis, a cruciferous plant containing sulphur, which it evidently elaborated from a soil rich in sulphate of lime. At Macedon the railway leaves the shore, and proceeds through shallow cuttings of surface soil to Carrickfergus; a short way from which place it branches off towards Ballymena, and going inland we come to the first cuttings through rocks, at Mossley. Here the section through the trap rock is very instructive, as a portion of the earth's surface is ripped open in a way that enables us to observe the phenomena very closely. The surface soil is from six to ten feet in thickness, and contains loose pieces of trap of a large size; underneath is the trap rock in situ, which, near the summit of the cutting, has a bedded appearance, and contains many white veins formed by infiltration. It is very hard, especially in the upper beds, and is also amygdaloidal in its mass, containing vast quantities of imbedded minerals, as steatite, calcareous spar, and several kinds of zeolites; some portions of the trap are loose grained, and in this state they exhibit very instructively the minerals augite and feldspar, of which the mass of the trap is composed. Descending in the cutting, rubbly beds are interlaced with the hard beds, the whole being generally

horizontal; the lower portions are very red coloured, and towards the eastward it has sometimes an arenaceous aspect. The concretions are of all shapes; but the structure, especially of the hard, is generally trihedral, as may be frequently observed in other localities. Towards the westward the beds become more inclined in that direction, and are sometimes of a greenish colour. We often see masses of a concentric structure, having hard nuclei, with softer matter about them; these concentrics are often visible in the middle of the beds exposed at the sides of the cutting, and exhibit a very beautiful appearance.

On leaving Mossley the railway cuttings are, for a considerable way, through superficial soil and bog. We observe frequently rolled pieces of chalk and flint in the soil, the occurrence of which can only be explained by there having been at one period a denudation in the neighbourhood, and large portions of the chalk formation swept away, leaving debris behind it. This denudation will account for some of the open spaces in the hills about Belfast, and the occurrence of chalk and flint gravel not only in that neighbourhood, but in the opposite county of Down, where it is very abundant.

The next interesting cutting through trap is in Ballypallady, at Steenson's quarry. The trap here presents a beautiful appearance, being hard, amygdaloidal, and very rich in zeolites, especially chabasie of a very fine description. As at Mossley, the upper part of the trap has a bedded aspect; but the whole mass is formed of concretions, generally having greenish steatite in the interstices. These concretions seem to be largest near the surface. In this quarry is a curious vein of ochreous-coloured trap, almost perpendicular. The embedded zeolites are extremely fine, and the mineral collector would here obtain a rich harvest.

On leaving Ballypallady, the railway passes along an embankment, on which are many pieces of an ochreous substance; the remarkable appearance of which at once strikes the geologist, who becomes curious as to where the like occur in situ. His curiosity is gratified at the next cutting in Ballyhartfield, which is the most remarkable on the whole line of railway, and is perhaps one of the most interesting sections afforded by any line of railway in this country.

At the eastern end of the cutting at Ballyhartfield the trap comes down to the bottom, rising as we go westward, and covering by a

thickness of only a few feet the subjacent beds. It frequently contains concentric concretions, similar to those in the other cutting, but much finer, sometimes giving it a rude columnar aspect. It contains many druses, in which are steatite, carbonate of lime, mesotype, and chabasie—the steatite sometimes occupying the middle of the druse, surrounded with one of the other minerals. Under this is a seam of dark buff ochre or lithomarge, succeeded by a black seam affording, according to the analysis of Dr. Hodges, Professor of Chemistry in the Belfast Institution, about nine per cent. of carbonaceous matter. Under this are several beds of ochres of various colours, red, lilac, buff, brown, &c.; some beautifully speckled; the whole presenting, before the sides were soiled over, an appearance resembling a painted geological model; in fact it is almost impossible to convey in words an idea of the geological beauty, (so to say,) of this section. Throughout these ochres there are many concentric concretions similar to those in the trap, and which are very remarkable objects; the nuclei being sometimes trap with layers of ochre about it, and sometimes the entire concentric is composed of ochre; one was very remarkable, its centre being of a light blue colour, with thin yellow surrounding layers. The following is the result of the analysis of this ochre by Dr. Hodges:—

Silica, ...	26.0
Alumina, ...	26.93
Per oxyd iron, ...	35.57
Magnesia, with a trace of lime, ..	0.73
Water, ...	10.33
Loss, ...	0.44
	100.00

This ochre is of frequent occurrence in other places in the county of Antrim, and from the quantity of iron which it contains, it has become an object of interest in an industrial point of view. At Newton Crommelin experiments were made on a large scale, for the purpose of smelting it with peat charcoal, and it yielded excellent iron, but for so far no work has been established for the purpose of commerce. It might also be easily manufactured into a pigment.

The section at Ballyhartfield displayed some interesting whin dykes, in the vicinity of which the concentric concretions above

mentioned generally become more numerous; between the dykes and the adjoining beds there is sometimes a seam of earthy matter. In the overlying trap, as well as in the dykes, there are thin veins of a white substance, evidently formed by infiltration, the analysis of it showing it to contain eighty-three per cent. of carbonate of lime. Before leaving Ballyhartfield it may be right to observe, that it is the only cutting on the line of railway in which the trap is wholly cut through, so as to give a good idea of the beds underneath.

Proceeding westward into the townland of Ballymartin, the railway passes through a cutting somewhat similar to that in Ballyhartfield. Here the trap has a bedded appearance, and is somewhat decomposed; a blackish clay underlies it, sometimes eighteen inches thick. There is also a dyke, and several concentric concretions, one of which was three feet in diameter. Proceeding farther in the course of the railway, the next cutting is through the upper part of the trap, after which there is no deep cutting through rocks for the rest of the line.

The next remarkable appearance is at Templepatrick, where, under the embankment, at a bridge across the old Belfast road, is a bed of light-coloured compact feldspar. This bed seems to have escaped observation, as it is not recorded by any geologist. It is of no great extent, and is evidently a subordinate bed in the trap, which is found in the railway cutting at both terminations of the feldspar. It was analysed by Mr. W. B. Ritchie, of Belfast, who found its composition to be—

Silica, ...	69.250
Alumina, ...	16.350
Potash	3.150
Soda, ...	4.400
Magnesia, ...	2.450
Protoxyd Manganese, ...	0.300
Lime, ...	0.700
Water, ...	3.400
	100.000

This bed of feldspar is highly deserving of observation, as it may in some degree account for the occurrence of trachyte, composed chiefly of feldspar, which is found in different parts of the Antrim trap district. A considerable extent of it, of a porphyritic character,

occurs in the hills called the Sandybraes, about five miles from Templetatrick, and from the occurrence of boulders both of compact feldspar and trachyte in the cuttings of the railway for several miles west of Templepatrick, there must have been former beds in other places, which have been denuded, and in all probability there are others concealed by the surface soil.

As trap may be regarded as a mixture of feldspar with augite or hornblende, the occurrence of subordinate beds of feldspar may be explained by the circumstance of the other mineral being absent under the conditions in which the igneous rock was formed.

Proceeding onwards towards Antrim, at the cutting near Mr. Chaine's cottage, the work was carried fifty feet through beds of gravel dipping about north-west, under which was a bed of loose boulder stones, in which there was found, about forty feet in from the face of the cutting, a mass of a kind of dry straw, a very puzzling phenomenon, as it is difficult to account for its occurrence in such a position under such a mass of superincumbent gravel. The boulders in which it was found were of the usual local character, trap and the above-mentioned compact feldspar.

Going nearer towards the town of Antrim there are tolerably deep cuttings through gravel hills, the gravel consisting of trap, ochre, feldspar, chalk and flint, all evidently derived from the neighbourhood. There is also much sand intermingled with clay that seems to have resulted from decomposed trap, and there are frequently alternating layers of sand and fine gravel; sometimes rolled chalk fossils are found in the cuttings. There must have been a denudation of chalk towards Lough Neagh, as pieces of it are found in the soil all about Antrim, and as far as Magherabeg, four miles onwards to Ballymena, beyond which Mr. Robert Young, the assistant engineer who superintended the cuttings, informed me he did not observe any.

Between Antrim and Ballymena the railway cutting is through drift and clay, with a single exception at Drumsough, where the cutting is for a short way through trap rock. Throughout the whole extent of this part of the line, there is found to be a blue clay underlying the local drift. This clay being so extensive, and occurring invariably under the drift, renders it probable that it is an ancient lacustrine deposit, showing a different condition of the surface formerly, but as yet too few facts have been brought to light

to come to any certain conclusion. Underneath it is the trap rock, as was proved by a cutting entirely through it at Tullygarry when the trap was reached. Between this clay and the drift there are frequently seams of sand, in which are often found pieces of fossil wood resembling those of Lough Neagh in various degrees of fossilization, from almost recent to hard stone. This occurrence of petrified wood is an additional argument in favour of the blue clay being a lacustrine deposit. In this clay at the Irish hill near Ballymena, there was found a rolled fossil resembling the Unio Listeri of the lias formation, which is a very puzzling fact, considering that no lias is now known nearer than the sea coast.

In the drift between Antrim and Randalstown, there are boulders of mica slate, granite, ironstone and sandstone, all of which must have come from Derry or Tyrone. Mr. Bryce, in a communication to this Society soon after its commencement, mentioned some facts corroborative of the supposition of a drift of boulders from the north-west over this part of Ireland, and the fact of the occurrence of those just mentioned near Randalstown would be an additional argument in its favour. Nearer Ballymena the boulders seemed to be all trap. Mr. Young, who observed closely during the time the cuttings were made, could perceive no other.

The only other fact worth relating is, that between Antrim and Ballymena the drift often encloses portions of bog, as if there had been a bog at one time put in motion and broken in pieces, which were arrested in a lake of mud. It is singular, that some years ago a bog near Randalstown was moved from its place, which still bears the name of "Moving Bog." Similar catastrophes have consequently occurred both in ancient and modern times.

AT THE

ANNUAL GENERAL MEETING,

HELD ON

WEDNESDAY, FEBRUARY 14th, 1849,

THOMAS OLDHAM, ESQ. PRESIDENT, IN THE CHAIR.

The following Report from the Council was read :—

IN compliance with annual custom, your Council have to offer to you their report on the progress of the Society during the past year.

At the commencement of last session you are aware that this Society had moved into the University, the Rev. Dr. Lloyd and the Rev. Mr. Graves having both offered to your Council any accommodation which their rooms could afford. Your Council, after consideration, determined to accept Dr. Lloyd's offer, and took advantage of the excellent room in No. 35, College, which is now occupied by your books, maps, &c., and in which your Council has regularly held its meetings. The liberal offer of Professor Graves was consequently declined, with the warm thanks of the Council. Subsequently finding that the lecture room in the engineering school—the use of which had been liberally accorded to the Society for its evening meetings, by the Board of the University—was not well adapted for such meetings, it was resolved, that the evening meetings also should be held in the Council room, which, though not very well suited for meetings, has been found sufficiently comfortable hitherto.

Towards the close of the session the College was occupied by military, and the public mind much unsettled, so that it appeared to your Council that the succeeding meetings for the session could neither be held with convenience or utility; they therefore deemed it advisable to adjourn the two meetings which should have taken place in May and June. The present session was opened at the

usual period in November, by an address from your President on the progress and prospects of the Society, to which address your Council refers you with much gratification.

During the past year three new members have been added to your Society.

Your Treasurer's accounts, which are annexed, exhibit a balance in favour of the Society of £62. 8s. 5½d.

Abstract of Accounts of Geological Society, for the year ending February, 1849.

Dr.	£.	s.	d.	Cr.	£.	s.	d.
To Balance in Treasurer's hands on last year's Account,	39	6	9¼	By sundry small expences, per the Secretary's Book,	4	17	4
— One Life Subscription,	10	0	0	By Mr. S. B. Oldham's account for Printing, &c. for last year,	26	0	6
— Annual Subscriptions, including arrears,	70	0	0	By Porter's Wages, eight months to Oct., 1847,	8	0	0
— Produce of Articles of Furniture sold,	0	8	0	By Mr. S. B. Oldham's account for Printing, &c. for this year,	7	17	3
				By Sundry small expenses per book, including Porter's Wages,	7	3	3
				By Collector's Poundage on Subscriptions,	3	8	0
				By Balance in favour of the Society,	62	8	5¼
	£119	14	9¼		£119	14	9¼

We have examined the above account, and find it correct, with balance in Treasurer's hands, £62. 8s. 5¼d.

21st February, 1849.

ROBERT CALLWELL.
W. H. HARVEY,

DONATIONS

RECEIVED SINCE THE LAST ANNIVERSARY.

1848.

Mar. 8.—Two fine Septaria, handed over to Museum, T.C.D., presented by R. Mallet, Esq.

May 3.—Specimens of Shale, with ripple marks, from Milltown Malbay, presented by Rev. Professor Graves.

London Philosophical Society Report for 1846—7, presented by the Society.

Quarterly Journal of Geological Society, 1st May and 1st August, 1848, presented by the Society.

Memoirs of Geological Survey, 2 parts, vol. 2, presented by the First Commissioner of Woods and Forests, per Sir H. De La Beche.

Reports of the Literary and Philosophical Society, Liverpool, presented by the Society.

Reports of Geological and Polytechnic Society of Yorkshire, 1845—6, by Society.

The Geological Map of the Co. of Wicklow—Plan of the Ovoca mines—four sheets of horizontal sections, published by the Geological Survey of Ireland, presented by the Chief Commissioners of Woods and Forests, through Sir Henry De La Beche.

The Mining Journal, by the Editor.

Report of the British Association for the Advancement of Science, for 1847, presented by the Association.

Report of the Proceedings of the Geological and Polytechnic Society of West-Riding of Yorkshire, (Leeds,) presented by the Society, 14th November.

Quarterly Journal of Geological Society, for November, 1848, presented by the Society.

Transactions of the Royal Scottish Society of Arts, vol. 3, parts 2 and 3, by the Society.

Wissenschaftliche Beobachtungen auf einer reise in das Petschora-land, from Count Keyserling, per Sir R. I. Muchison.

The Mining Journal for the past year, by the Editor.

Quarterly Journal of Geological Society, February, presented by the Society.

Resolved.—That the Reports now read be confirmed, and such parts of them, together with the Treasurer's accounts, as the Council may think fit, be printed, and circulated among the Members.

A ballot then took place, when the following gentlemen were elected Officers of the Society for the ensuing year:—

President.

PROFESSOR OLDHAM.

Vice-Presidents.

SIR H. T. DE LA BECHE, C.B.
JAMES APJOHN, ESQ. M.D.
REV. H. LLOYD, D.D. S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
LT. COL. PORTLOCK, R.E.

Treasurers.

WM. EDINGTON, ESQ.
S. DOWNING, ESQ.

Secretaries.

ROBERT BALL, ESQ.
ROBERT MALLET, ESQ.

Council.

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ.
THOMAS HUTTON, ESQ.
GEORGE WILKINSON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN,
MATTHEW D'ARCY, ESQ.
CAPTAIN LARCOM, R.E.
F. W. BURTON, ESQ.
REV. C. GRAVES, F.T.C.D.
REV. S. HAUGHTON, F.T.C.D.
RICHARD GRIFFITH, ESQ.
PROFESSOR HARVEY,
JOHN KELLY ESQ.
PROFESSOR HARRISSON, M.D.

The President then read the ANNUAL ADDRESS. After the address had been concluded, the following Resolutions were unanimously passed:—

"That the cordial thanks of the Society be presented to the President, for his constant exertion in the cause of the Society during the past year."

"That the warmest thanks of the Society be presented to the several Officers of the Society, for their zealous attention and endeavours to promote the objects of the Society during the past year."

The Society then adjourned.

ADDRESS.

The established custom of your Society, Gentlemen, devolves upon your President the duty of annually laying before you a brief statement of your progress, and of the advance of the science, for the cultivation of which you are associated.

It is to me a source of sincere gratification, that I am able to announce to you, that our Society has progressed during the past year. The memorable events of that period are no doubt fresh in the recollection of all; and although science acknowledges no politics, it is not, amid the bustle and anxiety of unceasing change—amid the upsetting of all established order—amid the crash of kingdoms and the ruin of the ordinary ties of society, that we can fairly look for the progress of knowledge, and the increase of learning. The mind cannot readily revert from the harassing anxieties of thoughts and cares which are impressed upon it by the general aspect of affairs around, to the useful and continuous investigations of science. And dead, indeed, to all the emotions of pity and of charity, must that heart have been, which could have watched, unmoved, the painful scenes of the past year. We *are* not, therefore, we could not be, surprised to find that the wonted energy of our members was in a slight degree diminished; and that several, who before were our most constant and steady supporters, have been compelled to absent themselves from our meetings, by the almost incessant demands upon their time and exertion, which the state of those around them involved.

You are also aware, that during the period of excitement and dreaded disturbance of last year, many of our public buildings were wisely occupied by her Majesty's troops, and the University among the number. It was, therefore, considered desirable to suspend the

meetings of this Society for two evenings. On all the other evenings of meeting, however, I am glad to inform you, that we were fully occupied with matter of interest and importance, that new members, (scarcely to be expected under the circumstances,) have been added to our body, and that the Treasurer's accounts show a considerable balance in favour of the Society.

This appears to me, gentlemen, a very strong acknowledgment of the value of our Association, and of the interest which many are beginning to take in our pursuits. We are satisfied that that interest once excited, cannot diminish. As our knowledge increases, the enjoyments connected with it increase too; and to none, save those who have been in some degree admitted to the shrine of nature, is the intensity of that calm, and deep, and soul-enjoyed delight known, with which they turn from the ever-varied torments of petty dissensions, and increasing contests which surround them here, to the contemplation of the works of Him "with whom is no variableness, neither shadow of turning." Into what utter insignificance do the revolutions of earth's kingdoms sink, when contrasted with those mightier revolutions which geology opens up to our view. How rapidly does the pride of man sink before the conviction which such discoveries impress upon him. Such pursuits are not, then, without their moral influence; and the heavenly harmony which they produce, amid the jar and discord of things around, is not the least delightful resource which they afford.

There are, gentlemen, two courses open to your President, on such occasions as the present; either to confine himself to a simple analysis and review of the matter which has been brought before the Society during the year; or to take a general review of the progress which has been made here and elsewhere in our science, and its allied pursuits. The latter, although unquestionably the more difficult task, and one for which many of the necessary means are wanting in this city, would yet appear so much the more useful, that, however imperfectly, I shall prefer giving you in some degree a summary of what has been thus done, to a dry detail of the points laid before ourselves alone, with most of which, I must presume that you are already acquainted.

The intimate connexion which exists between all branches of our enquiries—a connexion which is every day becoming more close and defined—renders it exceedingly difficult to adopt any classification of

subjects, which will not be in many respects objectionable. No memoir on descriptive geology would be considered complete without an accompanying investigation of the organic remains, (if any) contained in the rocks described; or a careful examination of the peculiar mineral arrangements exhibited. We may, however, divide our enquiries, with some advantage, into those belonging more properly to descriptive geology, mineralogy and its applications, including what may be denoted chemical geology, and palæontology; while there would yet remain a very important branch of our studies, including all the practical and useful applications of the scientific principles established. I shall endeavour in some degree to follow this classification.

Descriptive Geology.

The continuation of M. Andrè Dumont's description of the rocks of the Ardennes, and the Rhine, Brabant, &c., has been published during the past year;* the first portion having appeared in 1847. This detailed paper is characterized by an account of minute lithological and mineralogical description, rarely met with in geological papers of the present time; and taken in connexion with the author's former valuable description of the province of Liege, has added much to our knowledge of the mineral structure of those interesting districts, and has tended to elucidate several points over which some doubts hung. Having in the former portion of his treatise described the "*terrain ardennais,*" or what he considers the silurian rocks of that country, and which he divided into three systems or groups—

The systeme Devillien,
" Revinien,
" Salmien,

so named from the localities where they were found best developed, M. Dumont now enters on the consideration of the "*terrain rhenan,*" which he considers the equivalent of the Devonian system of English authors. This formation he also subdivides into three groups or systems—

1.	Systeme	Gedinnien,	1st lower,
	"	"	2nd upper,
2.	"	Coblentzien,	1st lower, or Taunusien,
	"	"	2nd. lower, or Hünsdruckien,
3.	"	Ahrien.	

* Mem. de l' Acad: Roy: de Belgium. tom. xxii.

The prevailing mineral structures are sandstone, quartz, conglomerate, slates, with occasional bands of limestone.

In this classification, or rather in the referring these rocks to the English representatives, as M. Dumont has done, it may be recollected that he differs entirely from Sir R. Murchison and Professor Sedgwick, who in their memoir "on the distribution and classification of the older or palæozoic rocks of the north of Germany," (read in 1840,) came to the definite conclusion, that these rocks all belonged to the silurian and cambrian group, and summed up this portion of their paper in the following words:—

"1. That considered on a broad scale, the succession of a natural group of strata, and the successive natural groups of fossils, are in approximate accordance.

"2. That as the broad areas of the physical groups of strata are ill defined, so also are the boundaries of the fossil groups ill defined, and pass into one another.

"3. That as there are no great mineralogical interruption of the deposits, producing a discontinuity or want of conformity among the masses, so also there seems to be no want of continuity among the groups of the great palæozoic series of animal forms."*

The lists of fossils, confessedly incomplete, which Professor Dumont gives, are not sufficient to decide this question, although the group as given has as much a devonian aspect as silurian; but he grounds his classification on an important physical fact: namely, that there is, he states, a very distinct and marked unconformability between the rocks of the *systeme ardennais,* (said to be Cambrian, by Murchison, and Sedgwick,) and the *systeme rhenan;* while all the subdivisions of each of these formations, as compared among themselves, are perfectly conformable.

This is an important fact, not seen by Murchison and Sedgwick; and though by no means sufficient grounds in itself, for referring either of the groups to the parallel that M. Dumont assumes, points to a remarkable change in conditions during the period of the formation of this great series of rocks. However this question may be finally settled by a more full and complete investigation of the fossils, M. Dumont has given a very detailed and carefully drawn up description of the mineral structure of the rocks. Nor are such enquiries,

* Trans. Geol. Soc. London, Vol. VI. Page 283.

by any means, confined in their interest to the locality to which they refer, but bear most importantly on English geology; and on that great question which must soon be more definitely settled, and for the determination of which, Ireland will in all probability afford the best key—of how far the devonian system can be recognized *as a system.* Its domain has been invaded from below by the silurian group, and the character of the important fossils from the carboniferous slates and yellow sandstone of Mr. Griffith, seem to point to an equal invasion from above. The south and south-west of Ireland will, in all probability, prove the means of establishing the true divisions of these groups.

The Rev. W. Clarke* commenting on the description of Australian fossils, by Mr. M'Coy, published in 1847, and the conclusions arrived at, (that the coal beds of that country were of the age of our oolitic period, and had been formed after a long interval had elapsed subsequently to the production of the palæozoic rocks of the same district,) endeavours to prove that this cannot be the case; for the, beds of coal are regularly interpolated in the series from which the older fossils have been derived, and has furnished further illustrations of the subject.

A somewhat analogous case is the disputed occurrence of belemnites in the same series as true coal-measure plants in the Alps of Savoy.

In November, Mr. Bunbury brought this case before the Geological Society of London. So long since as 1828, M. Elie De Beaumont had stated, that in the Tarentaise beds of black schist, which contained remains of ferns and other plants identical with those found in the English and French coal formations, were interstratified with beds of limestone, containing true belemnites. He referred the whole group to the age of the lias. M. Brongniart distinguished seventeen forms of the plants, only two of which were peculiar. Mr. Bunbury has also identified several with plants found in our, and in the American, coal fields. Sir R. Murchison has equally acknowledged, that the coal plants appear to lie in the same beds with the belemnites; and though not offering a definite opinion, seems to think that E. De Beaumont's identification of these beds, at Petit cœur, with the lias, is correct.

* Annals Nat. His. Sep. 1848.

Mr. Sharpe, on the same evening, described the occurrence of beds of anthracite, near Oporto, containing vegetable impressions, strongly resembling those of the coal measures under slates, in which numerous fossils were found, many of which were identical with lower-silurian fossils of northern Europe. And that thus the coal-producing beds of Oporto are in the same series of rocks, as with us are referred to the silurian formations. It need not be insisted on here, that the term "coal formation," if intended to imply a definite position in the series of stratified rocks, is worse than useless. That the conditions favourable for the abundant growth of vegetable productions, and for the subsequent entombing of those plants, under circumstances tending to effect that peculiar change in their composition, which has resulted in the formation of coal, that these conditions have been frequently repeated in certain places, and after long intervals of time, is well known to geologists, and might, *a priori*, have been anticipated. We know that the slight traces of such conditions, which the occurrence of small portions or thin layers of jet exhibit in Yorkshire, become more marked in the thicker beds of coals intercalated with oolitic beds in Sutherlandshire. There is, therefore, nothing to surprise us in the fact of beds of coal being found associated in other countries with older rocks, than those with which they occur here; but the extension of the flora, which in these countries characterizes the newer secondary rocks, into the older groups of rocks which occur in Australia, adds another remarkable instance to the peculiarities which the geological character of that district presents; and offers a most striking and most valuable hint to geologists, on the importance of studying the succession of rocks in each country, by an examination of that country alone, before they venture to force them into a parallelism with the series which may have been described in other districts.

The great proposition of Smith—that formations, and even beds, can be recognized as being of cotemporary formation at great distances, by the identity of the fossil remains contained in them, is only true when limited to areas, which appear to have been geographically united, or the same; and even then is not *strictly* correct either; but on the other hand, the occurrence of the same organic remains in beds separated geographically by such intervals, as that between us and Australia, or even Oporto, instead of proving, or even going to prove, the synchronism of the formation of the

beds in both places, proves *precisely the opposite;* and any attempt to establish the identity of the period of the formation of the rocks from an identity of the organisms peculiar to them, must fail, and fail, simply because founded on erroneous reasoning. Take, for instance, the existing faunæ of these two countries. Were fossiliferous beds being formed now in the Australian islands, subjected to examination by an English geologist, who was unacquainted with the existing fauna of that district, he would find in them, among a large number of organic remains peculiar to them, others extremely similar to those which in this country belong to the oolitic group, (trigoniæ, marsupial animals, &c. &c.) and from this might conclude that these beds were of the same age as our oolitic beds; but how erroneously I need not point out.

Again, in the very oldest rocks which we have, many species are known, common to this country, to northern Europe, and to America; now some of these appear much earlier in the silurian series in Germany than with us; others, again, are found in lower beds with us than on the Continent; and the same laws hold with regard to America. These species are, therefore, considered as separately, Germanic, British, or American species, that is, to have had their first origin or appearance in these countries, and their appearance in other countries, can only have been *after the lapse of a sufficient time* to permit of their distribution.

From similar reasons, the occurrence of such cases of fossils, which in these countries belong to distinct systems associated in the same beds, rather suggest important facts and laws as regards the mode or rapidity of distribution of the various species or genera of animals and plants, than any real contradiction to the established facts of geology. It is only when the analogy of existing nature is forgotten, or overlooked, that we are liable to be led astray by such facts. This, and this alone, is the source of all our knowledge with respect to the existence of former periods; and this, and this alone, can, therefore, be the true guide in such investigations.

Bearing on rocks of similar age to those which M. Dumont has described in the memoir to which I have referred, the valuable summaries given by Professor Ramsay and Mr. Aveline, on the structure of parts of north and south Wales,* and by Mr. Jukes and

* Quar. Jour. Geol. Soc. London, April, 1848. No. 16, page 294.

Mr. Selwyn, on the country extending from Cader Idris to Moelsiabod,* possess an interest for the Irish geologist, quite independently of their importance, as containing the result of the detailed and accurate examination of the district in connexion with the Geological Survey of Great Britain. During the year, I had myself also the honour of laying before this Society the results of the examination of the County of Wicklow; and these papers of my colleagues, are peculiarly valuable as illustrating by the examination of a country in which the series can be much more carefully made out, owing to the much smaller amount of detrital covering, the same succession of rocks, on the large scale, which are recognizable here. In Mr. Ramsay's paper, a case of unconformability in the silurian series, (the caradoc system resting transgressively on the lower beds,) is pointed out, which may recall the similar fact noticed by Dumont. And in this and the other communication we have a succession pointed out, which can be almost perfectly paralleled at this side of the channel. Thus the Barmouth and Harlech sandstones are the undoubted representatives of the similar rocks, which occur in our neighbourhood, at Howth, Bray-head, Devil's Glen, &c. &c. "The trappean group," is equally represented in Wicklow, as our map will show; and the valuable communications of Professor Forbes to this Society, during the past and preceding year, have shown clearly, that we have in more places than one, the representatives of the "Bala" beds also. I would also refer, with pleasure, to the important memoir of my colleague, Mr. Phillips, as bearing closely on the investigation of similar districts in Ireland; I can, however, only allude to these papers for reasons which will be obvious.

In May last, Mr. Moore brought before the Geological Society of London some fossils, derived from the old slate and grit beds of Wigtonshire and Ayrshire, which, on a comparison by Mr. Salter, were found to agree in part with fossils from the similar rocks in Wicklow and Wexford. It is remarkable also, that the slaty system of this portion of Scotland has the same general strike to east north-east, that the rocks of Wicklow and Wexford have; but they appear to differ, according to Mr. Moore's account, in not having any true slaty cleavage, which abounds in the south-east of Ireland. What may have been the cause of the prevalence of this structure in one

* Quar. Jour. Geol. Soc. London, April, 1848, No. 16, Page 300.

portion of a district, and its absence in another, while both seem composed of precisely similar rocks, and to have been subjected to similar disturbances, is a question opening up many points of interesting research.

Although not read within the last year, yet, as it has only been published then, we would refer to the papers,* by Mr. Binney, of Manchester, whose zeal and energy in the examination of his neighbourhood are well known to British geologists. In a paper, "On the origin of coal," Mr. Binney has embodied the results of a careful investigation of the relations of the coal field about Manchester. The coal measures are stated to be at least six thousand six hundred feet in thickness; that there are in this, one hundred and twenty different seams of coal; and that in the floor of all which Mr. Binney has seen, (eighty-four in number,) remains of *stigmaria ficoides* have been found. This important and general fact was first made known by Mr. Logan, with reference to the South Wales coal field.† Mr. Binney also endeavours to trace the currents which may have acted during the formation of the coal, as connected with a gradual subsidence of land, and concludes that, in most cases, the vegetables from the mineralization of which coal has been formed, were aquatic. Such papers of local detail and minute information, only to be acquired by a long and continued residence, are of great value.

Mr. Binney has also contributed a "Sketch of the geology of Low Furness, Lancashire," in which he describes the several rocks which occur in the district, "between the mouths of the Leven and Duddon, bounded on the north by a line from Ireleth to Ulverstone, and on the south by Morecambe Bay," and notices the interesting mines of Hœmatite, so long and so profitably worked in that district. He concludes by pointing out the great probability of there being a coal field underlying the southern and western portions of Low Furness.‡ It is in this way, by pointing out the probabilities of a successful application of enterprise, rather than by actually exhibiting the results of such, that our science can essentially aid the progress of our social condition, and increase the resources of our country.

* Lit. and Phil. Soc. of Manchester, Vol. VIII. New Series, Page 148.

† Geol. Trans. Lon. Vol. VI. Page 491.

‡ Mem. Lit. and Phil. Soc. Manchester, Vol. VIII. Page 423., &c.

Before passing to the consideration of the additions made to our knowledge of the more recent sedimentary rocks, we must delay for a moment to allude to an important communication made during the past year, first to the British Association at Swansea, and subsequently in an enlarged form, to the Geological Society of London, by Professor H. D. Rogers. We cannot speak in terms of too high praise of the ability displayed by Professor Rogers, in the beautiful illustrations with which his communication was accompanied, and the eloquent and masterly manner in which his views were enunciated. The state survey of Pensylvania, which has been executed by Professor Rogers and his colleagues, formed the groundwork of this paper; but the views announced were by no means limited to this district. Touching the descriptive portion of the paper, Professor Rogers pointed out the general accordance in succession, which the rocks of North America present, as compared with those of Europe; he stated the many reasons which had led them to conclude, that at the period of the formation of the palæozoic group of that country, there had existed an ancient continent, where now is the Atlantic; the strata further west than the Apallachian chain being the deep sea representatives of the more shallow water deposits found in that range. That after the elevation of a great portion of this region, the sea still covered the whole of Florida, the plains of Arkansas, extended up the Missouri, and along the Atlantic plain to New Jersey. Over this area was deposited first the cretaceous, and then the tertiary series. Professor Rogers pointed out the remarkable circumstance, that along the western boundary of the unfossiliferous rocks, which occur between the tertiary plain and the Apallachian chain, and for a length of one hundred and ten to one hundred and fifty miles, the "*newer rocks all dip under the older*." This remarkable fact had first been explained by Professor Rogers, who showed that it was due to the folding over of the rocks. To describe this a little more in detail; the Appalachian zone has a mean breadth of one hundred and fifty miles, and is stated to consist of five distinct and parallel belts. Crossing them from south-east to north-west, it is found that the form of the flexures or contortions of the rocks gradually alters; in the first two belts, the palæozoic rocks are doubled into sharp, closely compressed alternate folds, which dip, as a whole, at high angles to the south-east, or *towards* the chief source of disturbance; dykes, and mineral veins,

parallel to the strike of the beds abound here. In the third belt, or the great Appallachian valley, the oblique flexures or folds are somewhat less compressed, and the inverted or north-west sides of each anticlinal curve come nearer to a vertical position. In the fourth belt, or that of the great Appalachian chain, the flexures gradually expand, and the steepness on the north-west side of the anticlinal arches gradually diminishes. And in the fifth belt, that of the bituminous coal regions of the Alleghany and Cumberland mountains, the curves dilate and subside into broad symmetrical undulations with very gentle dips. The "axes planes" of these curvatures, therefore, or those planes which bisect the anticlinal and synclinal flexures, dip in the more plicated belts invariably to the south-east, and only approach the vertical when the curves become symmetrical, and the flexures flatten down: that is, the prevailing dip is *towards* the source of disturbance. These folds are also stated to lie in groups, each group having a certain distinctive character belonging to it.

The author next shows, that there are two systems of dislocations; one, small short fractures, perpendicular to the strike of the beds; and another, of enormous dislocations, extending for great lengths, parallel to the folds or axes of those flexures. These latter are said to occur almost invariably *at the synclinal folds*, or *at some point in the inverted leg of the anticlinal*, thus causing older strata to lean unconformably on newer ones. Some of these dislocations are said to cover eight thousand feet of strata.

The planes of cleavage are also stated to dip, on the whole, in the direction of the axes planes of the flexures; and with a dip approximately parallel to the dip of these planes. The same rules were stated to be applicable to the Alps, the Rhine, &c., and to all such disturbed districts. Such are the principal facts stated by Professor Rogers in his important communication.

To account for these, the author proposes to explain the great flexures of all disturbed districts, by supposing that "the thin and flexible crust of the earth has been at successive periods exposed to excessive tension, and has ruptured along lines." This rupture, or sudden relief of tension, would produce in the liquid mass beneath the crust, *two receding sets of huge waves of translation, which would throw the crust into corresponding undulations;* and at the same time press, or partially carry forward with them, the two pul-

sating zones in the directions of the advancing waves. During this wave-like motion, the crust below each trough, or concave bend, would crack and open downwards, and melted matter would rush in and fill the wedge-shaped fissures, and partially congealing would assist, in combination with other pressures, to prevent the mass from flattening out again; and thus the temporary flexures would be braced into permanent arches. Then "each succeeding set of similar billows of translation, starting from the same or parallel lines of rupture, would, by acting on the flexures already formed, contract their horizontal width, increase their curvature, and augment the difference in their anticlinal dips, even to the extent of a complete inversion of the forward side, with production of parallel oblique folding." I have quoted these words from the abstract of Professor Rogers' paper given in the Athenæum,* which, from my own recollection, and from notes taken at the time of his reading his paper to the British Association at Swansea, appears to me to represent his views accurately, because I wished to convey these views as clearly and fully as possible; and probably we will obtain even a clearer insight into his opinions, by taking, in connexion with these, the words of the same author, in originally announcing his views at the British Association meeting, at Cork, in 1843, when he said, that the wave-like motion of the earth's surface during an earthquake, is of the nature of an "actual billowy pulsation in the molten matter upon which they suppose the crust of the earth floats, engendered by a linear or focal disruption, and immediate collapse of the crust, accompanied by the explosive escape of highly elastic vapour," and they then speak of "progressive waves of oscillation," thus produced, &c. &c.†

Now the untenability of such an idea of motion, as applied to earthquakes, has been so fully, and so satisfactorily shown, by Mr. Mallet, in his able essay "On the dynamics of earthquakes,"‡ that it would be needless for me to enter upon the question, or point out the inapplicability of such reasoning to explain the phenomena of contortions as here seen. Professor Rogers has himself seen one of the difficulties, and has attempted to account for it. He has obviously seen, that if his notion of such billowy waves be correct,

* Athen. No. 1101, 1848, Page 1210. † Brit. Ass. Reports, 1843, Page 57.
‡ Trans. Roy. Irish Acad. Vol. XXI.

the undulations or flexures of the crust must be only temporary, and to account for their being rendered permanent, he introduces the notion of the curved portions breaking, and the molten matter being forced into these fissures, and thus bracing the flexures up into, permanent arches. A little further, however, when arguing "against the commonly received notion of the elevation and wedging asunder of the crust by intrusion of melted igneous matter," he contends, "that a fluid cannot act mechanically as a wedge." Now if this be true in one case, it surely must be equally true in the other; and therefore, the whole idea of permanency being given to such flexures by such means, falls to the ground; or, as the only other alternative, the commonly received notion is equally admissible with that of Professor Rogers.

But all these arguments are based on an assumption which we must examine a little more closely: namely, that these rocks thus twisted, flexured, and contorted, have floated on a fluid mass of molten matter. But how came they there? Does Professor Rogers suppose that these rocks are the result of the cooling down or congealing, as he calls it, of the molten mass, of which he probably conceives the earth to have originally consisted? On the contrary, he admits them to be mechanical and sedimentary rocks; they must, therefore, have been formed *from*, and deposited *upon*, previously existing solid materials. Where, then, are these? If they thus float on a fiery ocean, why have not the portions undisturbed, or at least so slightly disturbed, also been effected. That molten matter has existed there is clearly shown by the phenomena of the igneous rocks, but that these series of curved strata, extending for one hundred and fifty miles by one thousand three hundred, ever has floated on a sea of molten matter, (for to give the slightest colour of probability to the hypothesis, this sea of fire must have extended over the whole area equally,) is, I believe, a perfectly gratuitous assumption, for which we have no foundation whatever in geological facts. It must be remembered, that this is totally different from any abstract question as to the condition of the central portion of the earth's mass.

It may be asked, then, how otherwise can you account for such phenomena of twisting and curving; and for these phenomena following a definite law, as has been shown? Now, without at all admitting the justice of the reasoning, which would require us to

admit an explanation which appears physically improbable, because in the present state of our knowledge, we might not be able to offer a more satisfactory one, I still think that a little consideration of the ordinary forces which have been supposed to act in such cases, and of the mode in which those forces must operate, will explain many of the facts. It is not needful here, that we should enquire into the nature of the forces which have in such numerous cases exerted a powerful effect on the bedded rocks in the direction of the planes of bedding, or which, in other words, have produced lateral pressure. That such forces have acted, is granted by every one. All that concerns the present enquiry is simply, *granting the existence of such a pressure, what will be the results consequent on it in the mass of bedded rocks on which it acts.* But before discussing this question, there is one point to which it is needful to refer. Sir James Hall, who first pointed out by the simple experiment of layers of coloured cloth, pressed by a force from the side, the phenomena of contortion, seems to have been under the impression, that it was perfectly essential for the production of such foldings, that there should be a superincumbent weight, other than that of the atmosphere: and this has been again and again repeated by subsequent writers. Now any one who chooses to try the experiment, will most readily satisfy himself, that the presence of such a weight is by no means required for the production of flexures; it is only needed that the layer or layers should have a greater freedom to move in one direction than in another. This being the case, suppose a pressure applied at one end of such a series of beds, what will be the result? At first, compression only will take place; the amount of this compression depending on the original texture of the mass compressed. If the pressure be continued, the particles of which the mass is composed, having now been compressed into the smallest space which they can occupy, must move in some other direction; this direction being necessarily, in all cases of such rock compressions, upwards or outwards; (the point of the mass, relatively to the origin of pressure, at which such motion will first commence, will depend on many considerations, into which I shall not enter at present;) but it will clearly be, comparatively speaking, and under ordinary circumstances, near to the origin of pressure. Once diverging, these particles, and necessarily that portion of the mass formed of them, must follow the new direction which the particles have assumed;

that is, there must be a curving upwards in the mass. But while this curving proceeds to develope itself, the direct pressure or compression in the plane of the layers or beds is continued, and continued until the particles, in a more distant part of the mass, having been fully compressed, must, equally with the first, move in some new direction; and must, from the conditions of the problem, equally with the first, produce a tendency to curve upwards in the mass; this curve being necessarily developed in a line nearly parallel to the first. Such curves will be repeated with gradually diminished power, as we proceed further from the source of pressure. Now the particles or portion of the mass, thus moved from their position in the plane of the layer, having a tendency to move upwards communicated to them, have also their original motion, or a tendency to move onwards; they must, therefore, move in the direction of the resultant of these unequal forces, this resultant direction varying with the relative intensity of the forces; but in all cases having a tendency to make the particles move forward, or to make them over-ride one another; or in other words, to render the curves unsymmetrical, having an inclination forwards, or their "axes planes" directed *towards* the source of the pressure; precisely the fact observed by Professor Rogers; the amount of these flexures, their sharpness, and their inclination, will all vary with the intensity and continuity of the pressure.

But the limits of bending of such masses will soon be reached, and fractures must ensue; as a matter of necessity, these fractures will occur at the weakest point in the mass, or the points of least resistance; now *these points, in such a case, will clearly be the top or sharp bend of the curve towards the forward angle of it,* and *the bottom of the same limb of the arch;* (because here the two motions communicated to the particles will be most opposed one to the other;) but these are precisely the places in which Professor Rogers has shown that such faults occur; but which, even granting the origin of the flexures in waves such as he supposes, could not easily be accounted for on that supposition.

In all this, we have been considering the consequences resulting from the exertion simply of pressure, acting only in one direction; but this is not the case in such motions; as we have to deal with two forces, *one* acting in the direction of the radius of the earth, or tending to elevate simply; and the *other*, the consequence of

this, acting in the direction of the circumference; the resultant of these is, therefore, the true force which we have to consider; but this will only render the conclusions I have stated above more probable. It is extremely difficult,* without the aid of diagrams, fully to convey one's meaning on such a point; but I trust I have, at least in some degree, made myself intelligible. I shall in all probability resume the subject more in detail, at some of the meetings of the Society.

Professor Rogers has further applied the facts observed in the States, to account for the occurrence of cleavage. He supposes that each plicated belt of strata thus being the principal channel, through which molten matter and heated vapours passed, as being the most fractured and broken portion of the crust, there were formed thus alternate series of hotter and colder planes, exerting an agency analogous to a thermo-electric pile, and inducing those polarities of the particles, which Sedgwick and Herschel have thought the cause of cleavage. I would suggest further, that the motions which I have endeavoured to show must have resulted from the operation of a lateral pressure, will go far to account for those distinct cases of motion among the particles, which Professor Phillips first pointed out in 1843, and which Mr. Sharp has more recently attempted to reduce to rules, and also for many other phenomena connected with this very interesting question.

I may also refer to the law regarding cleavage planes, which I myself announced to this Society last year, as proved by researches in this country; that their dip in the main, corresponds, in its direction, with that of the planes of bedding of the rocks in which they occur.

But while we cannot admit the theoretical portion of Professor Rogers' valuable paper, we are greatly indebted to him for a clear and lucid enunciation of the facts of contortion, ascertained over a very wide area, and in a district where nature's works appear to be all moulded on a scale of grandeur unparalleled in the old world. What elevating conceptions of the mightiness of the forces called into play in the production of such phenomena as the geologist has to deal with, do we gain from an examination of districts such as

* A section illustrative of the structure of the district described by Professor Rogers, will be found in Lyell's Travels in North America, Vol. I. Page 92.

those described by Professor Rogers, where amid the unceasing variety, and apparently inextricable confusion, into which the rocks are thrown, we yet find all reduced to symmetry and law.

We pass now to the consideration of the additions made to our knowledge of the newer secondary and tertiary formations.

Mr. Ormerod has given an account of the great salt field of Cheshire, which is extremely valuable, from the amount and detail of the facts it contains; and as affording the only really valuable data we have yet had, for reasoning on the interesting question involved in the formation of these curious deposits.

The valuable memoirs of M. V. Raulin, on the geological structure of the Sancerrois, part of the old region of Berry, have been published, in which the most ample details of the mineral and lithological characters of the upper oolite, the greensand, chalk, and tertiary rocks of that district are given, and their parallelism with, and difference from, rocks of similar age in other districts, and the several elevations and disturbances to which they have been subjected, pointed out.*

M. Joseph Delbos, of Bourdeaux, has described in detail, the freshwater limestone of the basin of the Gironde, its peculiar character, and mode of occurrence along with the marine deposits of the same area. He describes the *molasse* as composed of alternations of clay, sand, and sometimes of limestone, the lower portion being principally clays, with occasional beds of limestone; above this, sands, with sandy clay, and, at top, thin clays. As regards the mode of accumulation of these curious deposits, the author advances the following opinions:—

1. That at the epoch, when the molasse was deposited, the eastern part of the basin of the Gironde was covered by a great lake, into which many considerable supplies passed, which, during the period of their greatest force, brought down sands, and even gravels. These supplies had their source in granitic countries, as all the elements of that rock are found in the molasse.

2. That when the force of these supplies diminished so far, that they could no longer transport even fine sand, then mud, more or less pure, was deposited.

* Mem. Geol. Soc. France, tom. II. page 2.

3. That at the same time a deposit of lime was taking place in the lake, more or less abundant, according to the time and place: when the force of transport of the supplies, from any local circumstances, became nil, then nothing but limestone was deposited.

4. That at certain times, and at certain places, within the area, siliceous and ferruginous springs supplied the elements, by which the rocks had been cemented.

5. That on the borders of this lake there existed plants and mammals, the remains of which were carried in by the water.

After some valuable details, the author concludes, that all the molasse deposits, and the freshwater limestone of the tertiary basin of the south-west of France, are above the parallel of the *calcaire grossier* of Paris; this latter being represented by the limestone at Blay, in the basin of the Gironde, which limestone is characterized by the presence of orbitolites; and he then proceeds to parallel the other groups with those occurring near Paris. This memoir is a valuable addition to the knowledge of the structure and arrangement of the tertiary rocks of France.

The "great question of the day," as M. Boué has denominated the disputed poin tas to the position of the nummulitic limestones of the Continent, has naturally attracted great attention during the year. And at the most recent meetings of the Geological Society of London, Sir R. I. Murchison, entered upon the question at large; and bringing to bear upon it his extensive knowledge of European rocks, has pronounced very definitely on the subject. In the first portion of his paper, which occupied two evening meetings, Sir R. Murchison entered on the question of the age of the "flysch," of the Swiss geologists, the "macigno" of the Italians; and confirmed the opinion, long before expressed by himself, that along the flanks of the Alps there was a real transition from the upper secondary to the lower tertiary. Where undisturbed, the rocks are quite conformable, and pass (as in the neighbourhood of Bassano) from true greensand, or neocomian rocks, up through the white scaglia or chalk, into the nummulitic and shelly deposits of the Vicentin, which are acknowledged to be of lower tertiary age. Other conformable transitions from the chalk or scaglia, into nummulitic rocks, are also pointed out; and it is concluded, that the whole group of the flysch and macigno, though frequently of very varied mineral aspect, (often a true greensand,) is in reality of eocene age. No separation of mem-

bers in the series can, in a district like this, be presumed from a local unconformability. In the succeeding portion of the same communication, the author devoted himself to establishing the age of the "molasse" and "nagelflue" of the northern Alps; and after detailing the numerous observations in the Alps, the Appenines, the Carpathians, and extending to Egypt and Hindostan, he concludes, by expressing his conviction, *that the great nummulitic formation is truly and exclusively eocene;* and that in no case does it form any portion of the cretaceous series.

This is by no means a novel result. Such was the opinion of many geologists, and the determination by Professor Edward Forbes, that the so called nummulites of America really belonged to another genus, orbitolites, removed some of the difficulty surrounding the question. Thus, in the communication made to the Society of Friends of the Natural Sciences at Vienna, we find M. Morlot, who had travelled through Illyria, for the express purpose of determining the position of this nummulitic limestone, relatively to the fucoid sandstone of Vienna and Trieste, and to the chalk limestone with rudistes, publishing in 1847 his conclusions, which, without entering into their detail, established the fact, that the nummulitic limestone was in all cases over the limestone with rudistes, or the chalk.* More recently, M. Victor Raulin, discussing the question not from his own examination, but solely from published facts, and viewing it in detail, both as regarded the evidence of fossils, and the evidence derivable from the theory of elevations, concluded that the nummulitic group belonged to the eocene period, and to the period of elevation of the Monte Viso system, of which the direction was N. N. W., to S. S. E.† In a subsequent memoir, he enlarged and corrected this classification, in which all the upper groups were equally given; but still he confirmed the position of the "*terrain a nummulites*" as eocene. The same author added much to the knowledge of local details by his paper, on the freshwater limestones of the Department de l' Aude;‡ and M. Delbos by his notice on the fahluns of the south-west of France, in which they are made miocene, and the nummulitic proup below them, lower miocene. M. Elie

* Rosthon arrived at different conclusions; Leonhard and Bronn's Jahrbuch, 1848, page 434.

† Bull. Soc. Geol. France, 10th January, 1848, page 128.

‡ Do. do. 19th January, 1848, page 428.

De Beaumont again, though placing all the nummulitic series in the eocene group, thinks, that with reference to its fossils, it may be divided into several groups.* Similarly we find Leymerie, D'Archiac, and Boué, contributing to establish the same facts. M. Hebert also by his papers on the deposits between the white chalk and calcaire-grossier of the Paris basin;† and still earlier, M. Roualt, in his careful description of the fossils from the eocene formation in the vicinity of Paris, have adopted the same views, all placing the nummulites in the eocene period. M. De Verneuil also had announced his conclusion, that no nummulites were found in the chalk series, but that they were all true eocene fossils.‡

But while the opinions of all geologists, who had examined the question at all, were centering on this solution, it yet remained for Sir R. Murchison to bring together all those local observations, and local conclusions, and uniting all in one, to state the general result, that all the nummulitic formations are eocene. This he has done with all that boldness of grasp, and generality of result which has characterized his former labours in geology, and he has unquestionably tended much to advance the progress of sound classification as applied to these rocks. It may, however, be fairly doubted, whether in this he has not in some degree, perhaps most correctly, outstripped his evidence, and drawn his conclusions more from impressions than from actual proofs. For instance, all the classification is based upon the supposition, that the scaglia can be fully and completely identified with the white chalk of England; for if the summit of the cretaceous system be not established, it is obvious that the base of the tertiary is equally uncertain, when the rocks form a continuous and conformable series. The fossil evidence is not yet made known—a few gryphææ are stated to be the only fossils common to the two groups, no *characteristic* fossils of the chalk being found in the nummulitic group: but what is a characteristic fossil of the chalk series. Is it one, which, in northern Europe and England, is confined to that series? But *here* it is perfectly established by natural history reasonings, that some considerable interval of time had elapsed, between the formation of the

* Bull. Soc. Geol. France, June 5th, page 415.
† Ibid, page 388.
‡ Bull. d l' Acad. Roy. De Belgium, tom. XIV. part 2, page 337.

uppermost beds of the chalk, and the deposition of the lower beds of the tertiary; and during this period, may not the organisms which existed during the period of the upper chalk in this country, have continued to exist elsewhere, and been entombed in the deposits then formed. Besides the same reasoning I have above expressed with reference to coal plants, is applicable here; and we would *a priori* argue that the existence of these nummulites, over such an immense area, is in itself sufficient reason to make us question the true parallelism *in time* of all the formations, in which they occur. I state these views simply, to express the caution, which it appears to me needful to use before admitting any such general conclusion, without sifting narrowly the evidence on which it is based, and not with the least desire of throwing a doubt on Sir R. Murchison's conclusions, which would certainly remove many of the difficulties which have surrounded this question.

M. D'Archiac, the first volume of whose valuable history of geology, was published during 1847, has announced* to the Geological Society of France, the conclusions at which he has arrived, from a general and comprehensive examination of the phenomena of the quaternary or diluvian formation, including in this term, all the phenomena, organic or inorganic, of which there are traces, between the termination of the subapennine period, marked by the elevation of the great chain of the Alps, and the existing epoch. He has compared all the materials published on this subject for the last twenty-five years for Europe, Asia, America, north and south, and Australia, and has concluded—

1. That the phenomena of striæ, and polishing of rocks, taken in the wide sense, have preceded all the deposits of this epoch; and consequently the development of the marine, terrestrial, and lacustrine faunæ. If these striæ, &c. have been produced by glaciers, the marine shells called arctic, which are buried in the clays and sands, which cover them, are not cotemporary with the period of greatest cold, inasmuch as they are found in the very places where these glaciers must have been. These shells, therefore, which point to a lower temperature than what prevails in the same latitude now, prove a more elevated temperature, than what prevailed in the epoch which immediately preceded them.

* Bull. Soc. Geol. France, 21st February, 1848.

2. The terrestrial fauna of large pachyderms, ruminants, and carnivora, was likewise posterior to the phenomena of the striæ, and in fact to the shelly deposits spoken of. The cause of the destruction of this fauna, therefore, could not be, as sometimes alleged, the low temperature which produced the greatest extension of glaciers. This fauna, so remarkable for the size and variety of the animals, has lived like the preceding shells, between the time of the striæ-phenomenon, or the period of greatest presumed cold, and the cataclysm which destroyed them almost simultaneously in Europe, Asia, America, and Australia.

3. If the erratic deposits which contain these bones, were carried by currents proceeding from the ancient glaciers, it necessarily follows, that these last did not belong to the period of the greatest cold; they must at that time have been confined to the mountainous regions, to allow of the growth in the lower portions, not only of the mammals but also of the vegetation on which they lived. There was, therefore, a sensible increase, or elevation of the temperature, after the period of the greatest cold, as represented by the striation of the rocks.

4. The first erratic phenomena would be exerted more particularly in the northern zone of Europe and America, and they would be more general; the second affecting more particularly the temperate regions of the two hemispheres, have been more subjected to local influences, and in many points have had two distinct phases.

5. After the phenomena of striæ, there was a sensible sinking of the coasts of many points; and later, at the end of the quaternary epoch, an unequal rising of the same coasts, varying in amount up to one thousand five hundred, or three thousand feet, and in few cases accompanied by dislocations.

The author finally concludes, that none of the hypotheses proposed to explain the phenomena of the diluvian epoch, is sufficient singly to account for the facts observed, but that they have concurred, either simultaneously or successively, in producing the results. All the proofs and details, in support of these conclusions, are promised in the second volume of M. D'Archiac's history of the progress of geology.

M. Boué has endeavoured to trace back from observed geological phenomena, the climatal character at former geological periods; he seeks to establish that the position of the isothermal curves in the northern portion of the two hemispheres, was very similar to

what it is at present, even so far back as the jurassic period. Of this he adduces as proofs—

1. That the erratic blocks come much further south in N. America than they do in Europe, and so do the isothermal lines.

2. In the old alluvial and tertiary deposits, fossils identical with, or analogous to each other, do not occur at the same latitude in Europe as in America, but always in more northerly localities, corresponding to the curvatures of the isothermal lines; thus the fossils of New Jersey are analogued in England, Paris, and north of Germany; the fossils of the southern states are represented along the Mediterranean, and up to the middle of France.

3. Similar facts have been traced by Roemer, with regard to the cretaceous system; thus the chalk rocks of Texas have the aspect of the chalk of the Mediterranean—the chalk of New Jersey that of the north of Europe.

Similar facts might be traced with regard to the northern limits of the nummulites from Europe, through Egypt to Hindostan; and M. Boué concludes,* that however the temperature may have been higher for the earth, the same *comparative* climatal relations existed; and shows the importance of such conclusions, in the bearing they have on some of the great questions of physical geology, the change in position of the poles, &c. &c.

Into what inexpressible littleness do the workings of man sink, when brought into comparison with the laws thus enunciated—laws called into operation countless ages before him, and which have held unshaken dominion, amid all the mighty changes that have since left their mountain traces on the earth.

M. Jules Grange has also discussed the effect of meteorological and geographical causes in modifying the former extent of glaciers.†

Mr. Strachey, in the journal of the Asiatic Society, Bengal, gives a very interesting account of the glaciers in the Himalaya mountains, and describes the features as identical with those observed in the Alps of Switzerland by Professor James Forbes. Alluding to the notices by other observers in other districts of the occurrence of glaciers, from one of which the Ganges springs, he concludes, that in the Himalaya, as well as in the Alps, there must be a large area covered by glaciers. We may, therefore, confidently look forward to a

* Bull. Soc. Geol. Trans. 3d April, 1848, page 276.

† Comtes Rend. 1848, page 384.

very large accession of our knowledge of glacier phenomena, when this magnificent range of mountains shall have been carefully investigated, by many of those able observers which the Indian staff contains.

The views of Professor J. Forbes as to the analogy which exists between the motion of glacier ice, and that of a semi-fluid or viscous mass, have received additional illustrations by the observations of Mr. Milward on an extensive mud-slide at Malta, read to the geological section of the British Association at Swansea. In this case, a large quantity of mud heaped up against a bank, began gradually to slide forward; it then divided, and the upper portion moved forward over the under. Regular bands were formed on the surface, presenting an appearance of difference of structure, being alternately fine and coarse—quite analogous to the so called dirt-bands of glaciers—these rough and smooth bands forming very distinct ridges, waves, or wrinkles, on the surface. Mr. Milward does not explain this phenomenon, although he altogether rejects any explanation derived from a consideration of the existence of a supposed alternation originally, of beds of different texture; this alternation, if existing at all, being the *effect* of the same force which produced the waves or wrinkles, and not the *cause*. Professor J. Forbes, in his fifteenth letter on glaciers, has given an interesting comment on these observations of Mr. Milward, pointing out the perfect analogy which exists between this wrinkling of the mud in the slide, and the production of the less and more compact wave on the ice, and stating his belief that the phenomena of ridges or wrinkles is a general one, depending on the toughness of a semi-fluid or semi-solid mass, forcibly compelled to advance or extend itself. Professor J. Forbes, also gives many other illustrations of a similar production of wrinklings in a mass of matter thus moved, as in the case of shavings taken off metallic surfaces by a planing engine, &c.; and shews that this is due to the same kind of motion to which he had previously attributed the similar phenomena of glaciers—namely, to that upward and forward motion which the particles must have assumed when compelled to move. This is a motion precisely analogous to what I have endeavoured to show, will fully account for many of the phenomena of contortions and curvatures of strata, as set forth by Professor Rogers, and appears to me, one of those striking instances, in which observations of existing phenomena throw important light on the explanation of phenomena of geological periods; and which compel

us to see the unity of the laws which control the operations of matter, even though it be so different in appearance and in structure as are the ice of a glacier, and the solid mass of a quartz rock.

I need not allude to the rapidity or generality with which, after the eloquent descriptions of Agassiz, many persons were induced to attribute to similar phenomena and at different periods, appearances which, in some degree, resembled those presented by glaciers in the country of Switzerland.

The mounds of gravel and heaps of sand which cover the surface of our country, were called moraines, our "diluvium," our drift, the huge boulders which strew our plains—all were ice-borne; and the whole surface, with the exception of a few isolated points of our northern hemisphere, was held to be at one time, covered with an almost unbroken sheet of ice. A little further research, however, shewed the futility of such reasoning in many, indeed in most cases, and other causes were seen to have played an important part in the production of these striking phenomena. The subject is, however, by no means exhausted, and observers in all parts of the world are bringing together data for the solution of such questions.

M. Guyot has long been engaged in the important investigation of tracing back to their parent source, the numerous varieties of rock found scattered over the great plains, and in the valleys of the glacier country of central Europe; and after a most careful and detailed search, has published his conclusions, which are sufficiently striking. He finds that not only is the erratic block formation of the Alps divided into certain groups or erratic basins, the limits of which are perfectly distinct; but that in each of these distinct basins, the distribution of the different rocks found in it, has been subject to definite laws; that this law has had the same influence in the plains as in the valleys, and that the law is the same in *all* the basins, however varied the rocks may be. Thus a particular kind of rock abounds, in one portion of the basin, but is found rarely, if at all, in another. And the blocks of different kinds, on leaving the place of their origin, have a tendency to form parallel series; and when they reach the plain, though they spread considerably, they still preserve a respective disposition, analagous to that which they originally occupied—the blocks derived from the right flank of the valley, occupy in the plain the right side of the basin, and those of the left flank, the left side; those derived from the more central valleys, cover

central portions of the plain. M. Guyot shows that this law of distribution is conformable to that which regulates the arrangements of moraines in an actual glacier composed of many tributaries; and attributes this to the fact of the erratic blocks having been deposited by a glacier, which once covered the whole of this district. These results are certainly very remarkable, and there seems no reason to doubt the possibility of a sufficiently close identification of the rolled masses with their parent rock, especially in a district where the mineral character of the rocks is so marked, to admit of such a conclusion being justly drawn. That in each mountain-valley such a law of distribution should hold would be expected; but, that in the great plains, there should be even an approximation to such a law is an important fact. In connexion with the same districts as M. Guyot has made the particular subject of his descriptions, namely, the valleys of the Rhine and the Rhone, I would refer to a short, but very interesting paper read by Mr. Robert Chambers, to the Royal Society of Edinburgh, on the same districts, and in which, carrying out his favourite idea of the action of the sea at levels different from those it now occupies, he attributes many of the phenomena presented by the superficial deposits of these plains to such action; and concludes, with remarking most justly, that "perhaps it would be well, if in scientific speculation, we were to keep our eyes more open than they generally are to diversified causes for similar or nearly similar effects."

It is to be regretted that Mr. Chambers has not more fully acted up to his own suggestion in the larger work which he has published during the past year, on "Ancient sea margins," in which a vast amount of detail is brought together, and a great accumulation of instances to prove, that all round our coasts, and in America, Norway, France, &c. there are unquestionable proofs in the existence of ancient sea beaches, that the ocean once stood at varied and different elevations above its present level up to fifteen hundred feet; that these margins or beaches preserve throughout a constant level, (though not always visible) for all parts of this area; and that therefore the change in relative level has been effected, not by an elevation of the land, but by a depression of the waters of the ocean —a depression taking place by sudden shifts at successive times, with intervening periods of rest. This is, I believe, briefly the object of the author. I shall not detain you by any recapitulation of

* Jameson's Edin. Journal, 1848.

the very strong evidence on which previous writers have grounded their opinions in arriving at a precisely opposite view, namely, that the level of the ocean was, and must have been, far more constant than that of the land, for these views may be found very fully and clearly stated in many works; but I would simply state, that evidence of an infinitely stronger kind, and based upon observations of a much more accurate nature than those of Mr. Chambers, must be brought forward before his conclusions can be admitted. A series of facts, or at least of statements asserted to be facts, based on observations of such a loose nature—frequently mere approximations derived from originally erroneous data—can never be admitted as evidence in cases where the matter to be proved is such a fact, for instance, as the occurrence of two definite lines of sea marking, or old sea-beaches, occurring at levels above the present level of high water, say at six hundred and eighty-seven, and seven hundred and three feet; and these determined in countries, separated by such an interval as Scotland and America. And yet, based on three or four observations of this kind, Mr. Chambers hesitates not to place some little ledge of superficial deposits, found in Scotland at half a dozen places, in exact parallel with those observed at Lake Erie, and to separate those occurring at the upper level, seven hundred and three feet, from those at the lower level, six hundred and eighty-seven, making them his two ancient sea-beaches, No. 33, and No. 34. This is a case taken at random from his book, but is, I think, amply sufficient to prove to any one who knows the limits of error of even careful levelling operations, unchecked by what are called tie-levels, that such loose and irregular determinations of level are utterly and entirely useless as a ground for any such conclusions as would establish a difference between two such bands at such distances, and the roughly ascertained difference of which was only sixteen feet in seven hundred. And this is by no means the strongest case that could be adduced. But Mr. Chambers has given us no clear notion of how he has in any case determined the question of what was, or what was not a sea margin. There are certain characters peculiar to a sea beach, not one of which he seems to have considered as necessary to be present; but he has, as it would appear—for he has not stated this clearly—considered that mere external outline has been sufficient at once to place all such flat topped accumulations of water-borne materials as he found in our superficial deposits in the

general category of ancient sea margins—with what justice any one, who has paid the least attention to such facts, can say. That the sea has exerted a long continued and powerful action on the solid rocks of the earth, at levels very different indeed from that which it now occupies, and even higher, comparatively speaking, than Mr. Chambers states, has been shown by many authors; and I have myself, laid before this Society during the past year, some interesting cases of this kind; but in all these cases, it has left undoubted marks of its presence. I may also be permitted to quote the words which I used several years since, (1844) in speaking of some of the very instances which Mr. Chambers quotes in our own neighbourhood, when I said, "that these deposits have been raised, is obvious; but that they are, or ever were *beaches*, is very questionable."*

I would also suggest to Mr. Chambers a careful examination of such facts as he will find represented by the excellent charts of our shores, published by the Admiralty. No fact is better known, than the large extent of ground covered by comparatively shallow water, which extends round all our coasts, and the suddenness with which the water becomes deep just beyond. A similar fact, Mr. Chambers will find repeated at certain intervals in such a way, that a section of the bottom would show definite portions of nearly flat sea bottom, and just beyond a sudden increase in the depth of water—this increase being of very varied amount. Now, let Mr. Chambers suppose all this brought up to view, or if he prefer it, suppose the sea removed from it, we would here have infinitely better and stronger evidence of a succession of sea margins or beaches, (if the form of the surface combined with the occurrence of marine remains, and the structure of the deposit be considered,) than any which Mr. Chambers has adduced; and yet, notwithstanding this apparent succession of beaches, there is not a single beach in the whole. This is one out of the many instances which might be quoted of the necessity which exists, before attempting to draw any induction from an accumulation of facts, to ascertain carefully whether these facts really belong to one and the same category.†

* Jour. Geol. Soc. Dublin, Vol. III.

† It would be foreign to our purpose to point out here, in any detail, how essential it is to prove that any "shelf" or "terrace" is of marine origin, or in other words, a "beach" or "sea margin," (for the words appear to be *assumed* by Mr. Chambers as synonymous) *before* speculating on the causes which have produced such shelves.

To Mr. Chambers, however, we owe much, for having brought the subject prominently before the public, and thus attracted increased attention to a series of phenomena of great interest and importance.

M. Omalius D'Halloy, in a note "*Sur les depots blocailleux,*" has proposed this name for all those deposits which contain a greater or less amount of angular fragments. These, according to him, are easily divided into two simple classes—one comprising brecciaform rocks; the other, in which the fragments are not, as it were, soldered together, but form a whole entirely composed of fragments. The author does not conceive it possible that the action of water has been the original cause of the production of these fragments, although subsequently it may have transported them; but that, in most cases, they were produced by the contractions of the mass, from desiccation or cooling, as in muds, &c., and this grand cause, aided by the disturbances which have taken place in the crust of the earth. The beautiful breccia of Tuscany (called the *Mischio di Seravezza*) in which angular fragments of white saccharine limestone, are tied together by a blueish paste of a pyroxenic character, forms a bed or portion of a bed between others of the ordinary saccharine limestone of the Apennines; and D'Halloy attempts to explain this phenomenon, by a reference to cases which sometimes occur in glass, where, resulting from a blow, or other such cause, we sometimes find a number of fragments enclosed in another portion, which remains unaffected: and he supposes that the matter which has filled in the cavities, has been injected from below in a state of igneous fluidity, and has, therefore, intruded itself into the bed which was fractured, but has not been able to force itself into those which offered greater resistance.

Another group of "*depots blocailleux,*" are those which accompany porphyries, basalts, &c. &c., and which the author attributes to the sudden cooling, and the consequent fracturing and breaking up of the outer coats of igneous rocks, and also the mechanical breaking of the same; the angular fragments thus produced being either again caught up in the fluid mass, or spread out in beds, more or less irregular, by the ocean. He then refers to a large class of rocks, puddingstones, &c.; and to account for the large amount of quartz found in them, the author has recourse to supposing the existence of siliceous springs, such as occur in Iceland, and which would deposit the

quartz; reasoning from the difficulty of accounting for the sources of this quartz, from any known deposits from which it could be derived. We have referred to this paper, as one among many instances in which the study of existing causes now in operation would readily have led the author to explanations very different, indeed, from those which he has given, and much more philosophically simple. The occurrence of such innumerable fragments of pure quartz in many of our conglomerates, has often excited the wonder of geological observers; but it is fully paralleled at the present day in the sand and gravel banks, which occur round our coasts. Take for instance the great deposits of sand in our own immediate neighbourhood, along the shores at Portmarnock, Malahide, &c.—sands, the composition of which would yield at least nine-tenths of pure silica in quartz grains. Whence, it may be asked, was all this derived? The rocks in the immediate neighbourhood are slates and limestones; and yet, although much of the quartz which enters into the composition of these sands may be derived from a distance, much has unquestionably come from the adjoining rocks. In looking at such results, as are now placed before our eyes, we are too apt to forget the necessity of tracing the successive steps in the processes leading to these results, as far as in our power; and thus we may omit to consider the facts that the accumulation of such heaps of silica is due to the circumstance, that the softer, and, therefore, more easily destructible, matter of the slates, &c. has been ground down, reduced to powder, and removed to a greater distance by the same forces, which have affected the quartz grains only to a slighter degree, in consequence of their more unyielding nature. And a close examination of even our fine sands, much more our coarser, will show that many of these grains of quartz are in some degree angular. It is indeed probable, nay, almost certain, that with quartz, and such other minerals, possessing great hardness, but at the same time considerable brittleness, the general mode in which masses are reduced to smaller grains, is by *fracture*, arising from the impinging of the masses against each other, and not by actual *wear*. In many cases, therefore, the comparative predominance of quartz fragments, in our old conglomerates and sandstones, is due simply to the fact, that the other and softer materials have been removed, while this has withstood the action of the agitating forces, which have distributed the masses.

Again, as regards those rocks in which the paste has a resemblance to, or is identical with, igneous products, the included fragments being also sometimes similar, although many facts, long since described by authors, attest the truth of the supposition, *a priori*, of D'Halloy, as to the breaking up of the surfaces of flows of molten matter, thus producing breccias, &c.; still we ought never to forget that in volcanic districts, at the present day, by far the greater portion of the mass of matter ejected, comes forth not in the form of couleès of lava, but as scoriæ, ashes and mud, and even frequently of perfectly formed crystals. Nor can we see any the slightest reason for supposing that the phenomena of older data were not similar; that we had not then, as now, showers of volcanic ashes, bombs, masses of rocks of various sizes, and flows of mud accompanying the exhibition of actually molten matter, and producing deposits originally similar to those now being formed in volcanic countries, but subsequently modified in appearance by infiltration, pressure, &c., and all the subsequent changes which have taken place. Our minds are frequently so much arrested by the striking and beautiful phenomena of dykes, and intrusions of igneous matter, at a period *subsequent* to the formation of the stratified rocks, with which they are associated, that we are too apt to forget that a similar exhibition of igneous matter may have taken place *cotemporaneously* with the mechanical deposition; and that thus we may have, and do have, igneous matter mixed up with the mechanical rocks, often in the most irregular and apparently arbitrary manner. Such cases, however, in no way compel us to seek for their explanation in intrusion, or forcible injections.

Connected with descriptive geology, I may refer to some communications to this Society, during the past year, which I had myself the pleasure of laying before you. In these I described, in some detail, the geological structure of the County of Wicklow, explained the mode of construction, and character of the map and sections illustrative of that structure recently published in connexion with the Geological Survey of Ireland, and pointed out their peculiarities. We have been enabled also to contribute from the labours of the officers of the Survey in other ways, as by M. Du Noyer's account of the very interesting section exposed at Fanghart, in the County of Down, where the phenomena of trap intrusions are so beautifully shown, and in which also the occurrence of the old red sandstone in that district was first made known.

But I allude to these communications for other reasons; for, arising out of some remarks at the November meeting of the Society, on the published sections of the Geological Survey, we had brought before us in December by Mr. Mallet, a full description of a proposition, (which he threw out as a suggestion in the first instance,) for the adoption of one uniform, and systematic principle, for laying down geological sections—a suggestion which appears to me of very great importance and value, and to which I must refer in a few words. Mr. Mallet stated very forcibly the objections to which the ordinary geological sections are open, and the uselessness of many of these for any purpose other than the mere illustration of some particular point of geological structure, and states his views as to what the real object of geological sections ought to be, namely, to give the physical features of the country correctly, and so lead to distinct ideas of the forces concerned in producing these—to give a true representation of the succession of strata; and further, to give economic information, such as relates to mines, agriculture, &c. These objects, Mr. Mallet believes, are not attained by the present system; and to accomplish such ends, he proposes, that all sections shall, in future, be laid down in lines due north and south, and east and west; or in latitude and longitude—that the several sections of the same district shall be laid down parallel to each other, and at equal distances apart, whether they be north and south, or east and west, the same horizontal and vertical scales being used, and half-tide level assumed as the datum.

When several such sections in both directions are laid down, they present a sectio-planographic, (to use an engineering phrase,) model of the district, and from such sets of normal sections any section in intermediate or diagonal direction can readily be inferred. As a brief mode of distinguishing such sections in description, the author proposes to call those sections which run north and south, or in latidude, *makrotome;* those passing east-west, or in longitude, *eurutome;* and these in any other direction in azimuth, *mesotome* sections. The author then concluded his communication, by briefly, but clearly and forcibly, pointing out the valuable results which might fairly be anticipated from the general adoption and completion of such a series of section for an entire country, and further for the whole globe; (his proposition essentially, including the idea, that such sections shall be continued across the sea, as well as the land;)

from the great geological features being brought into immediate co-ordination with the great cosmical forces which have tended to produce and modify these results. I must say I did not fully see the force of Mr. Mallet's suggestion thrown out as it was, in conversation, at our meeting in November; but having previously to the next meeting of the Society, at which he brought forward the matter more in detail, prepared sections on this general system of a portion of the County of Wicklow, from an examination of the sections of which the suggestion originated, I am fully satisfied that the method proposed is one of great value; and that a most important impulse would be given to the progress of physical geology, by the completion of such a series of sections. I have, however, some doubts as to the practicability of accomplishing it at present. There are few countries of which we have sufficiently accurate maps to enable such sections to be prepared, without enormous cost and trouble; for the British Isles—for Ireland especially, they could be made at a very trifling expenditure of either; but although it may require the lapse of years before geologists could, by possibility, be placed in possession of such sections for the globe, it would be extremely desirable that some such general system should be adopted, by which the labours of our fellow-workmen in all parts of the earth, could at once be brought into definite and symmetrical comparison, and by which the vast amount of research and toil now brought to bear on geological investigation, should be rendered useful, not only for the illustration of the detached districts examined, but as integral and definite portions of one grand system of illustration which should embrace the earth.

In the department of *Palæontology* we have, during the past year, had many additions to our knowledge, both of the peculiar forms of the fossil species, and of the laws which appear to have regulated their distribution at the period during which the rocks were being formed. To his valuable treatise, on the organization of trilobites, of which in 1846, the Ray Society issued an English edition, corrected and revised by the author, Burmeister has since added some important supplementary researches on these crustacea.*

During 1847, a work appeared on the trilobites of Bohemia, by

* D'Alton and Burmeister's Zeitung, 1848.

M.M. Hawle and Corda, but supposed to be almost entirely due to the latter author, in which the desire for genera-making has been carried to, if possible, a greater excess than ever. Nor can we omit to notice, in addition to the unsoundness of the author's views, the fact, that the book appears to have been an unjustifiable and unfair, because wilful, attempt to anticipate the labours of Barrande, whose treatise on the trilobites of Bohemia forms a very valuable addition to the knowledge of these interesting remains. In the Palæontological appendix to the descriptive memoir by Professor J. Philips, of the Malvern districts, drawn up in conjunction with Mr. Salter, some valuable additions to previous knowledge will be found.*

M. Alcide D'Orbigny has published his views on the classification of the very important group of brachiopoda. In his arrangement he adopts a dichotomous method, and therefore unavoidably brings together, or separates, the several genera into must unnatural groups. Mr. J. E. Gray has also† proposed a new arrangement of this important class. To Von Buch we are indebted for the earliest satisfactory illustrations of the fossils of this group, and subsequently the attention of many able naturalists has been directed to them. Mr. Gray's classification is founded on the character, position and arrangements of the oral arms.

Mr. Davidson has continued his very accurately drawn illustrations of the brachiopoda of the silurian system, in the Bulletin de la Societé Geologique de France, ‡a portion of which had been previously published in the London Geological Journal. In his present communication, we have accurate drawings and descriptions of twenty-five new species. In connexion with M. Bouchard Chantereaux, he has also§ illustrated very fully, by a beautiful series of specimens, the internal structure of the chalk fossil, originally named by G. Sowerby, *Magas pumilus,* and corrected several erroneous ideas concerning it ; and M. De Barrande has also continued his figures and descriptions of the silurian brachiopoda of Bohemia.||

Sir Philip Egerton ¶ has added to the knowledge of the fishes of

* Mem. Geol. Survey, Vol. II. part 1.
† Annals of Nat. History, December, 1848.
‡ Bull. de Soc. Geol. de France, 1848, 139.
§ Ibid, 1848, page 309, 8th May.
|| Haidinger's Naturwiss, Abhand, part 2.
¶ Quar. Jour. Geol. Soc. London, 1848, page. 302.

the older palœozoic rocks, by his description and figures of ptericthys, homothorax, &c.. Mr. Hugh Miller, universally known to geologists as the author of that delightful little work, "The Old Red Sand-stone," has continued his researches, and laid before the Physical Society of Edinburgh, some of his recent discoveries regarding the structure of asterolepis, dipterus, &c. The fossil fish of the same formation have received additional illustrations from Mr. M'Coy, our fellow member. He has added* three new genera, and twenty-one new species from this formation, (the old red;) and in another paper on fossil fishes from the carboniferous group, he has added to the already perhaps too large number, no less than eleven genera and forty-two species. As there are no figures of these species given, it is impossible to say how far the author is justified in such apparently minute separations.

In these papers, Mr. M'Coy has proposed a new family, the placodermi, and has pointed out a peculiarity in the formation of the tail, which peculiarity he has proposed to denote by the term diphycercal. We would thus have the homo-cercal, the heterocercal, and the diphycercal forms of tail, the latter characterised by there being, not only a spinal prolongation, but also, almost as great a development of the fin rays above as below the spinal prolongation.

Whether it be either desirable or needful to introduce new names for forms which appear to form only a passage or one step in a gradation between recognised types, must be decided by an examination of the specimens themselves, or of careful drawings.

H. Von Meyer, has given a useful summary of the fresh water fish of Bohemia, and the comparative species found at Gosau, Œningen, and other places.†

The fossils of the grauwacke formations of Thuringia, have been described and illustrated by Richter.

Our acquaintance with American palœontology, so far at least as concerns the older formations, has been greatly extended by the valuable and important work of Hall on the palœontology of New York. In alluding to this work, we must refer with great pleasure to the very splendid series of works illustrative of the Natural History of that State, published by the government of New York—

* Annals Nat. His. Nov. 1848, page 297.

† Leon. and Bronn's. Jahrbuch, 1848, page 432.

valuable from their detail, and important from the character and extent of the area which they illustrate. Since the earlier volumes on geology have been issued, great advances have been made in our knowledge of the silurian rocks in the old world, and Mr. Hall has fully availed himself of the increased resources placed at his disposal. Studying their own formations carefully, establishing their succession and relations, solely by a consideration of their true relative position, and other physical characters, and uniting with these enquiries, the careful and detailed study of the fossils contained therein, the American geologists have established for their own country, several distinct groups and subdivisions, which are in a great degree analagous to, or parallel with, those acknowledged in this country. I allude to this the more particularly as being an example of what appears the only true and sound method on which to conduct the geological investigatlon of any well defined district. It is only by seeking out the conditions under which, in that district, as compared with itself, the rocks have been formed that a knowledge of the successive modifications of those conditions, which have resulted in the successive formation of beds of varying lithological character, and containing remains of different and distinct organisms, can be arrived at. The attempt to force into parallelism with the subdivisions established in one country, those which may exist in another, and to found such conclusions on a comparison of a few fossils, or even a single fossil, (as has often been done,) found common to both, is unphilosophical and erroneous, and must inevitably result in, to a certain extent, concealing from our view the true nature of the problem. We cannot, therefore, too highly appreciate the independence with which the American formations have been studied, and compared one with another, and then, and not till then, compared with the known and established groups of other countries. In Hall's palæontology of New York, we have the results of such a comparison admirably brought before us in all its detail, and well illustrated. I cannot, however, enter into any detailed examination of this work, which is perfectly essential for the study of the silurian rocks of any country, and which will, therefore, be in the hands of many here.

We have had two important communications from Professor E. Forbes, before this Society, on the fossils from rocks of nearly the same age; one in which he pointed out the character and probable age of the fossiliferous limestones and slates at Portrane in this

county; and another, in which he describes a new genus of silurian or cambrian fossils, *(Oldhamia)* first made known by myself in 1844, as occurring in the very old rocks at Bray Head and other localities. I shall not here enter on the details of structure given by Professor Forbes, as the members will see all this in the Journal.

Passing from the older formations, Geinitz and Gutbier have given us a most important monograph on the fossils of the Permian system in Saxony, accompanied by excellent figures. This work fills up a blank in our science. Very few, indeed, of the organic remains of this group, containing the zechstein of German geologists, the magnesian limestone of our own country, and the rothliegende, have as yet been described. To Mr. King, of Newcastle, whose monograph on the magnesian limestone fossils of Durham, &c. is now passing through the press, for the Palæontographical Society, we are indebted for some—a few scattered notices have been given by others; and in Murchison's extensive work on Russia, several have been figured and described by De Verneuil. It was, indeed, from the great development of this group of rocks, in the district of Perm, that the name Permian was proposed by Sir R. Murchison, and has been very generally accepted. As the last stage of the palœozoic era, it forms an interesting series. The work of Geinitz and Gutbier, therefore, is a valuable addition on a much neglected portion of the stratified rocks. We would simply state the number of the several groups of which descriptions are given, which will suffice to show, that it is by far the best work on the fossils of the Permian system, we yet have—

Sauria	2	Radiata.	Echinodermata	1
Fish Ganoid	20		Crinoidea	2
,, Placoid	7		Polypi	8
Annulata	2	Plants.	Confervæ	6
Moll. Cephalopoda	2		Equisetacea	1
,, Gasteropoda	7		Ferns	9
Conchifera	13		Algæ	6
Brachiopoda	16			

making a total of one hundred and one species.*

Professor Naumann has announced the discovery of the permian

* Die Versteinerungen des Zechstein, und Rothliegende, oder des Permischen systems in Sachsen, 1848.

system at Oschatz, and noticed the peculiar and distinctive character of its flora.*

In connexion with this, we may notice Von Buch's little treatise on the ceratites or ammonites of the Muschelkalk, which appear to be only eight in number, forming a remarkable group characteristic of that rock.

In the upper groups of stratified rocks, we have equally gained great additions to our knowledge of their fauna and flora. Giebel has contributed to our acquaintance with the corals of the planer-mergel.† Milne Edwards' valuable systematic treatise, on the same group of fossils, has been, in part at least, published.‡

Vicomte D'Archiac has given an able and beautifully illustrated report on the fossils of that remarkable bed in the chalk series, known locally to the miners under the name of *Tourtia*,§ and which forms a deposit of not many feet in thickness, extending over a considerable area, in the chalk series, which rests immediately on the carboniferous rocks of the frontier of Belgium and France. A close examination of these fossils shows that they form a remarkable group, the larger portion of which were previously undescribed. The author had pointed out some of these facts in 1839, but the detailed description is now first given. His carefully drawn up list is prefaced by some interesting and valuable general remarks; especially on the microscopic structure of the shells of the terebratulæ, which in this deposit have a prodigious development and very great variety. Out of forty-eight described, thirty-four or three-fourths are new, besides, at least, twenty distinct varieties. This genus also contains fully one-fourth of the total number of fossils of every kind. And M. D'Archiac thinks, that if future research should confirm these results, this thin and limited deposit will form one of the most remarkable examples of such phenomena known. Referring to the labours of Von Buch, Deshayes, Carpenter, Glucker, and Morris, on the intimate structure of the shell, he points out a new division in which small granulations in relief are observed on the folia of the shell, instead of the minute perforations or punctures pointed out by Carpenter; to this he applies the term *arenacees*.

* Bull. Soc. Geol. France, 8th May, 1848, page 301.

† D'Alton and Burmeister's Zeitung, 1848.

‡ Annales des Sciences Naturelles.

§ Mem. Soc. Geol. France, 2nd Ser. tom. II., part 2.

There is another and different structure in many of the ribbed terebratulæ, only visible under a high power, which he calls *fibro-capillaire.* M. D'Archiac, however, only states these results as provisional, and as very incomplete, but which, when carried out in sufficient number and variety, may lead to important conclusions. He points this out the more especially, as the consideration of these internal structures, has afforded to that able naturalist, Mr. Morris, the groundwork of his proposed classification of the terebratulæ.

Next to the terebratulæ, the most abundant fossils in the "tourtia," belong to trochus, turbo, and pleurotomaria, and with their associated remains would appear to me to point to a shallow water deposit. The great prevalence of terebratulæ in some degree militates against this notion, for as a group the brachiopoda are deep-water shells; but Mr. J. B. Jukes, in his interesting account of the voyages of the Fly, has noticed a similar abundance of terebratulæ in shallow water, on the coasts of Australia.

Mr. F. Pictet,* has published an important memoir on the fossils of the lower cretaceous group of the neighbourhood of Geneva, especially of those of the age of the gault; of this only the portion including the cephalopoda, has as yet reached us. It contains full and carefully compiled descriptions of seventy-eight distinct species, of which twenty-nine are now for the first time described, and illustrated by well-executed lithographs. Such local catalogues furnish the best possible groundwork for accurate reasonings on the distribution of fossils, and the physical conditions under which they existed; and this detailed memoir of M. Pictet will add considerably to the already high character which he has acquired as the author of the valuable "Traitè elementaire de Palæontologie."

The new species are thus divided—

Turrilites	1
Ptychoceras	1
Hamites	6
Crioceras	1
Ammonites	17
Nautili	3
	29

M. Nyst, to whom we are already indebted for several valuable

* Mem. de la Soc. de Phys. Geneva, tom. XI. 2nd part.

contributions to our knowledge of the tertiaries of Belgium, has undertaken* an elaborate synopsis of all the species, living and fossil, of the family of the Arcaceæ. The portion already published, contains only the genus arca properly so called, as defined by Nyst, a second portion being promised, to include the other genera pectunculus, nucula, &c., belonging to the same family.

M. Nyst includes, under the generic group of Arca proper, all the Cucullœæ of Lamarck and others; the Byssoarcæ of Sowerby, the Isoarcæ of Münster, Dolabra, and Crenella of M'Coy, and some seven or eight genera proposed by J. E. Gray in 1840 and 1847. Taking this extended view of the genus, M. Nyst finds that arca, of which Lamarck only gives forty-eight species, is in reality represented by four hundred and fifty-nine species, or subtracting from this eighteen uncertain species by four hundred and forty-one. In examining the distribution geologically of these, M. Nyst finds—

1. That the genus arca appeared with the earliest fossiliferous rocks, being represented in the lower silurian by two species;* in the upper silurian by nine; and in the devonian by thirteen—in all twenty-four.

2. In the carboniferous system by twenty-six, all of which belong to the lower portion of the system.

3. In the permian we have three species—

1 in the lower,
2 in the middle,
0 in the upper.

4. In the triassic group, the number of species again increases to twelve, all in the middle group.

5. The jurassic group contains sixty-nine, of which nine are in the lias—

20 in the lower oolite,
34 in the middle,
6 in the upper.

6. That the cretaceous group appears to be that which contains the largest number, having in all one hundred and ten species, thus distributed—

27 in lower,
11 in middle,
63 in upper.

* Mem. de l' Acad. Roy. de Belgium. tom. XXII.

† To these we must add some since described, as *arca primitiva*, Phillips, Mem. Geol. Sur. Vol. II. part 1, page 366, plate XXI. 5, &c.

7. In the tertiary group we have ninety-six species, of which there are—

41 lower,
25 middle,
30 upper.

8. That the genus has acquired its maximum development in existing times, being represented by one hundred and two species, which, as regards geographical distribution, are thus divided—

27 in northern ocean,
93 in tropical seas,
7 in southern,
35 precise locality unknown.

This distribution is also remarkably definite, as only five are known to pass from one zone to another, viz.—three *(Arca, barbata, diluvii, lactea,)* from the northern to the equatorial, and two *(Arca, corbicula, semitorta,)* from the equatorial to the southern.

The subdivision of the genus pointed out by Mr. M'Coy, (Dolabra) is found confined to the lower palæozoic rocks, *(depots de transition.)* Cucullæa appears with the same group, and is there represented by ten species, but attains its maximum development in the cretaceous group, where it has thirty-nine representative species, and gradually dies out as we approach the existing period, as it has only five species in tertiary rocks, and two living. M. Nyst further asserts that no one species passes from one great group to another; that of the whole number only nineteen—which he considers have not been sufficiently examined, or identified—pass from one system to another, and that out of the whole number of living species, only thirteen have been found in the upper tertiary rocks.

The value of such a careful resumé of all published species, and the importance of such publications in detail, cannot be too highly estimated. It must be borne in mind, however, that such a synopsis, however accurate at the time of its publication, is liable to constant change, as our knowledge of the subject may increase; but its real importance consists in the facility it affords, and the inducement it offers, to the student to study and compare his own experiences with the records and observations of others, so as to confirm or modify their results, and so tend to eliminate errors, and attain a more perfect knowledge of the laws which regulated the distribution

and development of such organized creatures, at successive periods of the earth's history. While, therefore, we cannot agree with M. Nyst in some of his conclusions, as depending on identifications or distinctions, which we would not acknowledge, we recognize the value of his paper, and look forward with anticipation of results of equal interest to the publication of the second portion, containing the other genera, belonging to this family.

The same author has given a similar synoptical and systematic list of the genus Crassatella,* accompanied by a description of two new species, (C. astartiformis, and C. Bronnii,) both from the lower tertiary group.

Lamarck in 1818, described only nineteen species, including five now belonging to the genus *mesodesma*. M. Nyst's table shews seventy-one. Of these the geological distribution is as follows :—

Lower cretaceous,	5
Upper do.	17
Lower tertiary,	24
Upper do.	4
Living,	19

All the living species belong to warm climates, not one is found passing from the fossil to the existing period, nor is there one of the living species found fossil: further, not one is found common to any of the two systems.

Michelotti's† beautifully executed and accurate figures of the miocene tertiary fossils of North Italy, although published in 1847, may be noticed, and Heer's‡ description and plates of the insect remains found at Œningen and Radobog, in Croatia. M. J. Bosquet§ has described a new species of Hipponix from the chalk at Mæstricht, *H. Dunkeriana*, the first as yet known from that formation.

Mr. M'Coy has also given us a useful list of the mesozoic radiata, which he has been able to recognize as occurring in British strata, since the publication of Morris' most valuable list of British fossils. To the list of known species is prefixed a description of thirty-eight new species from the chalk and oolite formations, and one new

* Bull. de l' Acad. Roy. de Belgium, tom, XIV. part 2, page 116.

† Descr. des foss. des terrains miocene de L'Italie septen.

‡ Die Insekten fauna der Tertiargebilde von Œningen, und von Radobog in Croatien.

§ Bull. de l' Acad. Roy. de Belgium, tom. XIV. part 2.

genus, diplopodia. The grounds of these distinctions cannot be fairly estimated until Mr. M'Coy may favour us with accurate figures of the new species.*

As bearing on the same point, we may here allude to Mr. Lycett's excellent communication on the distribution of the fossils in the neighbourhood of Minchinhampton, in which much useful information is given. It is somewhat remarkable, and must have occurred to every one engaged in such enquiries, to find the very small number of the oolitic fossils which have been figured and described in Great Britain. Rich in most beautifully preserved specimens of almost endless variety, with its several subdivisions for the most part well marked and easily accessible, it is certainly rather surprising to find that the very series of beds which formed the groundwork of the important discoveries of Mr. Smith, and which may, therefore, be considered as classic ground in geology, should have received so little attention. We, therefore, hail with pleasure any contribution to our knowledge of their organic contents.

Mr. M'Coy has more recently† given a complete list of all the palæozoic corals and foraminifera he has observed from British strata. In this paper he has made eight new genera, and fifty-five new species, of corals, and one new foraminifer. Here, again, we have a series of names without any sufficient illustration, and we are, therefore, at a loss to know what value to attach to such distinctions. I have already in the address, with which at the request of the Council I opened the present session, insisted on the very injurious effect which such hastily compiled, and insufficiently illustrated lists have on the progress of our knowledge. To this paper, however, Mr. M'Coy has added a list of great value to Irish geologists, as it contains the localities and formations from which the specimens described and figured by him in the valuable synopsis of the carboniferous fossils of Ireland, published by Mr. Griffith were obtained. This list to a considerable extent supplies the deficiency so much felt in the Synopsis; but we are quite sure we express the wish of every one who has had occasion to consult Mr. Griffith and Mr. M'Coy's work, when we would earnestly urge Mr. Griffith to give to the public a more complete

* Annals. Nat. His. Dec. 1848.

† Annals Nat. His. Jan. and Feb. 1849.

and detailed description of these localities, and of the subdivisions he has established in the carboniferous group

Dr. Reuss has also given a splendidly illustrated memoir on the fossil polypiaria of the Vienna tertiaries,* which is an extremely valuable addition to the knowledge of fossil corals.

During the past year, in addition to the valuable papers, in the second volume of the memoirs of the Geological Survey, by Professor Forbes, the structure of the Pentremites has been illustrated by the discovery of F. Roemer,† who has found in specimens from Alabama, that the ambulacral pores were not orifices for the passage of membranous tubes, serving as organs of locomotion and respiration, as in the Echinida, but alimentary canals for a corresponding number of articulated tentacula, formed in the same manner as the arms of crinoids, shewing that these pentremites are true crinoids, and do not approach to the Echini. Mr. Yandell has made the same observation in Kentucky specimens, *(P. florealis.)*

Professor E. Forbes was led to a careful examination of the same group, while investigating the structure and analogies of the cystidea, and his conclusions, drawn from a much more general and higher consideration, than those of Roemer and Yandell, will be found, at length, in his most important paper, "on the Cystidea," (Mem. of Geol. Sur. vol. 2, part 2, page 523, &c.)

M. Pomel has established, after a careful investigation, the range of the Mastodons. He finds that the M. *angustidens* is confined, with the M. *buffonis*, to the pliocene rocks: M. *cuvieri* and *tapiroides* to the miocene. In Europe they are exclusively tertiary upper and middle. In America they are found with the remains of Elephants, (E. primigenius) in diluvium.‡

We must not omit a notice of Bronn's Index Palæontologicus, a general list of fossils with their synonyms, well executed, and very useful to students.

The Palæontographical Society, established (on principles similar to those which were found to work so successfully in the Ray Society,) for the publication of works illustrative of the palæontology of these countries, has, during the past year, issued its first volume, containing

* Haidinger. Naturwiss. Abhand.

† Bull. de la Soc. Geol. France, 1848, 17th April, page 296.

‡ Bull. Soc. Geol. France, 1848, 20th March, page 258.

the first portion of a monograph on the fossils of those British tertiary formations, known under the general name of the Crag. This portion includes the univalves only, and in it we find descriptions of two hundred and fifty species, illustrated by upwards of five hundred figures, engraved by G. B. Sowerby, jun. These, although by no means engraved in the best style, are amply sufficient for the identification of the species, and are accompanied by full and careful descriptions, by Mr. Searles V. Wood, whose catalogues of the fossils of this formation, published in the Annals of Natural History for 1840-1842, furnished the first general list which British geologists possessed of these remains. Mr. Wood has continued his researches up to the present time, and availed himself of all the aid which the labours of others in the same field could afford; and we thus have the history of these fossils brought up to the latest date, by one who has long and successfully laboured in the subject. Although not more than a few new species have been added, (ten or eleven,) still the great advantage of such a work consists rather in the facility of study it affords to the collector of such remains, and the obvious result which such a means of easy comparison must produce in tending to advance our knowledge of similar deposits. The great difficulty of identifying fossils, from the numerous works, detached, and frequently difficult to procure, which must be consulted, and the time which such a system of comparison necessarily occupies —time and labour, infinitely greater than any one who has not been actually engaged in such investigation could suppose—have constantly proved a bar to such studies; and we, therefore, have great pleasure in the prospect which the publication of such a series of monographs, as shall for the separate groups of fossiliferous rocks in the British Isles, bring together and arrange all the existing knowledge, and place it before the student in a condensed and easily accessible form affords. The various monographs furnished to the Society by authors distinguished for their devotion to such pursuits, promise to form a most valuable library of reference for the British student of Palæontology.

The beautifully illustrated work of our colleague, Dr. Harvey, on the British Algæ, which at once combines the most careful scientific descriptions and analyses of the species, with attractive notices of their habits and uses, continues to add to his well earned and high reputation, and proves useful and interesting, as well to the scientific algologist, as to the mere collector of our sea weeds.

During the past year, another group of our algæ has been brought before our notice in the treatise by Mr. Ralfs, on the British Desmidieæ. Long known by his able papers on this subject, read before the Botanical Society of Edinburgh, and published chiefly in the Annals of Natural History, (many of the illustrations and descriptions contained in which have since been appropriated by others) Mr. Ralfs has in the present work brought together and wrought out the entire knowledge of the subject up to the present time. The work is amply illustrated by plates of exceeding beauty and unequalled accuracy; the species are fully described; the microscopic structure accurately explained, and the actual measurements of the object in all cases given, (a novel and very valuable addition in such treatises.) In the introduction Mr. Ralfs discusses at length the question of the Animality and Vegetability of these organisms. The former view, supported by Ehrenberg, had been the prevalent one, but Mr. Ralfs, after a candid and manly discussion of the arguments on both sides, appears to have established the conclusion, that the Desmidieæ, must be regarded as "Algæ allied on the one side to the conjugatæ, by similarity of reproduction, and on the other to palmelleæ, by the usually complete transverse division, and by the presence of gelatine.* This work is of direct interest and value to geologists, from the occurrence in many places, and in some quantity, of fossil Desmidieæ, or portions of Desmidieæ. Thus Mr. Ralfs shows, I think, conclusively, that "the orbicular spinous bodies so frequent in flints are the fossil sporangia of Desmidieæ," pointing out the errors of Ehrenberg, in referring them to fossil Xanthidia.† Fossil fronds also of Desmidieæ have been found by Professor Bailey, in calcareous marls brought from New Hampshire and New York.‡

We cannot, however, consider that Mr. Ralfs has performed more than half his task, until we are favoured with a similar volume on the allied group of the Diatomaceæ, (of much greater interest and importance to the geologist;) and we hope that the universally expressed pleasure with which his present volume has been hailed,

* Ralfs Brit. Desmidieæ. Intr. page 36. Mr. Thwaite's valuable paper on the Diatomacea, and more resently on the Palmelleæ may also be referred to. Annals Nat. His. Nov. 1848.

† Ibid. page 12.

‡ Silliman's Amer. Jour. Vol. XLVIII. 340.

will encourage him speedily to accomplish its conclusion. That he has continued his researches in a similar direction, is shown by his recent communication on the mode of growth of Oscillatoria, and allied Genera, (Annals of Nat. History, January, 1849.) Mr. Dickie has described the occurrence of a considerable group of nearly forty diatomaceæ in the fossil state, in marl from Peterhead, Aberdeenshire.* And Mr. Williamson has described in detail, many diatomaceæ occurring, in abundance, along with other interesting microscopic objects, in the mud of the Levant.†

Ehrenberg also has continued his microscopical researches, and described the remarkable infusoria found in the stomach of a Peruvian freshwater fish. Previously he had examined several hundred fish, and very rarely had traced an abundance of infusoria in them; but this fish had a large amount (thirty-one species are given,) showing that it had lived on an infusorial mud.‡

In connexion with fossil botany, the most important contributions of the year have been the papers by Dr. Joseph Hooker, published in the memoirs of the Geological Survey of Great Britain, in which an able comparison of the flora of the carboniferous period with that of the present day is given, as well as a valuable resumé and discussion of our knowledge as to the nature and affinities of those remarkable vegetable fossils, called lepidostrobi. To these researches of my colleague, however, I cannot do more than allude, merely recommending the philosophical and exquisitely illustrated paper of Dr. Hooker, to the careful study of all interested in such enquiries.

M. Ch. Martins§ in a memoir on the vegetable colonization of the British Isles, Shetland, Faroe, and Iceland, after recapitulating and fully admitting the facts on which Professor E. Forbes founded his conclusions, in the very original and suggestive paper, "On the connexion between the distribution of the present fauna and flora of the British Isles, and the geological changes which have affected their area, &c., takes exception to the causes to which such facts have been referred, and seems to think, that oceanic currents, the action of winds, and the migration of birds, are quite sufficient to account for the phenomena. Without referring to the

* Ann. Nat. His. August, 1848.

† Mem. Lit. and Phil. Soc. Manchester, Vol. VIII. new series, 1848.

‡ Ann. Nat. His. June, 1848, 465.

§ Bibliotheque Univ. June, 1848.

all important fact, that in this case M. Martins has altogether overlooked, or at least omitted, the consideration of terrestrial or land animals; (although he admits the remarkable fact of their very peculiar distribution also,) I would simply remark, that the currents of the ocean to which he refers, chiefly naming the *gulf-stream*, would have just the opposite effect to that which he would attribute to them; its direction *in the main*, after it reaches the shores of Great Britain and Ireland, being *towards* and not *from* the south. It is quite impossible, therefore, to refer to its agency the transport of seeds from southern Europe. If the first origin of some of our plants were due to such agency, they should rather be Mexican and American plants than Portuguese and South-European plants; but they are in reality the latter and not the former. Again, the action of winds in transporting seeds is unquestionably considerable; but if they had been really the cause of any large portion of our flora, we should naturally, and I think justly, expect that (*cæteris paribus,*) the majority of those plants should be plants derivable from those countries from which the prevalent winds blew; now the prevailing direction of our winds is known to be from the south and west, while the *prevailing* character of our flora is *Germanic*, or of that type which is derived from, or at present characteristic of, countries lying just in the opposite direction. It would, therefore, appear to me, that while perfectly agreeing with M. Martins on the necessity of attributing their full value and importance to the agency of existing causes, we yet are compelled to believe that those causes, united with others, perhaps more important, have acted under such different circumstances, that we may justly admit the conclusion of Professor Forbes, and see that recent geological changes *have* left their traces in the peculiar grouping of our fauna and flora.

We may here allude to the very interesting fact, that since the date of Professor Forbes' paper, several plants have been added to the list of those already known in Ireland; and that these have all, in a most remarkable way, borne out his views. These discoveries have been made known by Dr. Harvey during the past year.*

* Thus, Dr. Harvey has announced the discovery of *Simethis bicolor*, *Kth.* found May, 1848, abundantly, on hills, and by the seaside, in peaty and in sandy soil, near Darrynane Abbey, by Mr. Thaddeus O'Malley: native of Portugal and shores of Mediterranean, not cultivated in Irish gardens. *Saxifraga andrewsii*, *Harv.*, remarkable new species, with the flowers of *S. nivalis*, and leaves resem-

In addition to the published contributions to our palæontological knowledge, I may add, that in a communication from Mr. Binney of Manchester, recently received, he states, that he thinks "he has found good evidence of reptilian remains from the British coal measures"—a very interesting and important addition, and confirmatory of recent discoveries on the Continent. Mr. Binney also writes, "that during last Autumn, in company with his friend, Mr. Rcbert Harkness, of March Hill, near Dumfries, he found the track of a new species of Rhynchosaurus in the Bunter Sandstein, in several quarries near Dumfries. The footmarks are very different from those of Corncockle Moor, described by Dr. Duncan:" and further, he has been pursuing the study of the Lepidodendra and Sigillaria, a subject on which we are already deeply indebted to Mr. Binney; and, after a good deal of cutting, has obtained a beautiful transverse section of Lepidodendron, showing clearly, that this plant had not only a vascular cylinder round the pith, but one also just under the bark, inducing Mr. Binney to think that the *Sigillaria elegans* of Brongniart, is nothing but a *lepidodendron*. I shall do nothing more than announce these interesting facts, waiting for the detailed publication of them by Mr. Binney.

Mr. J. M'Adam of Belfast, who has for some years been zealously bringing together a very large and valuable collection of the greensand fossils of the County of Antrim, is at present engaged in their examination, and hopes to be able to make known some of the results soon. He has found no representative of the lower greensand in that district.

I cannot leave the subject of palæontology without directing your attention to an important lecture delivered by Professor E. Forbes, at the beginning of last year, at the Royal Institution, London, on the question, whether genera have, like species, centres of distribution. Professor Forbes in this lecture carried out, and extended some views which he had previously announced with regard to distribution. Every *species* was shown to have necessarily occupied a single area, (however that area may have been subsequently broken up into detached portions,) within which there is some point or centre where that

bling those of the Swiss species, allied to *S. pyramidalis*, on Clune Mt. near Glen Cara, Kerry, found by Mr. W. Andrews. *Erica ciliaris*, Linn. found near Roundstone, Galway, by T. F. Bergin, Esq. 1846, growing with E. Mackaii in abundance, in flower in September.

species had its origin. Now the enquiries of zoologists, of botanists, and of palæontologists, all tend to show that in a similar way, groups of species or *genera*, occupied definite areas in geological space, as they did in geological time. Of this Professor Forbes gave numerous instances, both from the animal and vegetable kingdoms, instances in which this distribution could not be governed by elemental conditions. So far as research has gone, it would appear that each genus has occupied a definite *area in time*, which area in time is unique for such genus, apparently pointing by analogy to the inference, that where there is an apparently *double* area occupied by a genus in space, these double areas are only parts of a single area, now divided. Thus establishing the idea of areas of genera as to space, Professor E. Forbes discusses the question, whether such areas had centres—or in other words, points of maximum and points of origin; and shows the probability of such being the case, and of the point of origin of a genus being also its point of maximum, and possibly also of its final disappearance. The important effect which such enquiries must exert in influencing the philosophical study of palæontological phenomena, is too obvious, to need that I should insist upon it.

The important and complicated subject of volcanic action has, during the past year, received much attention. M. Perrey,* to whom we were previously indebted for several contributions to what may be called the statistics of earthquakes, has published a detailed and valuable catalogue of all earthquakes, which are recorded to have taken place in the Italian peninsula, from the fourth to the nineteenth century; or more particularly, from the year 325 to 1849, giving a total number of recorded shocks of one thousand three hundred and sixty-two. In reducing the results, of these laborious searches through the very many works and journals in which the records have been found, to the tabular form, the author has here, as in his former memoirs, considered all shocks, or commotions of the earth, which disturb the same country, during a greater or less period of time, but continuous for that period, as forming one single phenomenon—considering as *one* single shock, all the continuous shocks united which may have occurred in one and the same place, without an interval of more than eight consecutive hours, during one

* Mem. Couronnes, de l' Acad. Roy. de Belgium, Tom. XXII.

month: where they have been continued for more than one month, he takes one for each month; considering, however, as distinct those shocks which have affected distant localities, though nearly at the same time.

Tabulating in this way all the shocks noticed in the Italian peninsula for the period mentioned above, by months and by centuries, he finds the relative proportion for each season to be as follows:—

Winter, (January, February, March,) 359—Spring, 314—Summer, 265—Autumn, 284. For the six months, from 1st of October to 31st March, 650—from 1st April to 30th September, 581, being nearly the ratio of :: 9 : 8.

From this it appears that Winter preserves for the Italian peninsula, the preponderance which M. Perrey had already shown that it held in other physical regions of Europe. Autumn, however, instead of being second, has become third, in the order of frequency of earthquake shocks; Summer being here, as elsewhere, the least fruitful in subterraneous movements.

The author had previously found, in all his investigations of a similar character for the rest of Europe, that the number of the shocks for the six months from October to March, as compared with the number for the six months from April to September, had a ratio of 4 : 3—the present numbers give a ratio 4.5 : 4. Tables of the relative frequency of these for each month, and for separate periods, are also given. Out of the total number of one thousand three hundred and sixty-two, the direction in which the motion took place is only recorded for one hundred and sixty-three cases; discussing these few, however, as regards their direction, we find the following results:—

From North to S.	21	S. to N.	22
N.E. to S.W.	22	S.W. to N.E.	11
E. to W.	39	W. to E.	18
S.E. to N.W.	24	N.W. to S.E.	6

In taking the opposite directions together, that is, those from north to south, and those from south to north, and similarly with regard to the others, we have—

N. to S. and S. to N.	= 43	1.05
N.E. to S.W. and S.W. to N.E.	= 33	0.80
E. to W. and W. to E.	= 57	1.39
S.E. to N.W. and N.W. to S.E.	= 30	0.73

which would give the relative proportion nearly, as shown in the column above. From these numbers, and considering the cause of the movement, whatever it may, as in a certain degree proportioned in intensity to the number of instances in which each direction has been observed, these relative numbers may be considered as representing these forces, and thus we can determine the mean resultant direction of the movements. This the author has done, not only for the Italian peninsula, but also for the other well marked physical regions of which he had discussed the earthquake phenomena, and he tabulates the result. He alludes to the interest which such results have, taken in connexion with the the orographic and hydrographic systems of the districts given. We may mention one or two. Thus for the basin of the Rhone the mean resultant direction is south, 9° 44′ west; which is also as nearly as possible the mean direction of the river; similarly with the Rhine, south 7° 9′ east; for the Italian peninsula the mean direction given is, south, 72° east, also the mean direction of its mountain chain.*

M. Perrey has equally published the results of his researches as to the earthquakes which have affected the Iberian peninsula, and also gives a list of these recorded generally for the year 1847.† Of these there were ninety-one; out of this number only sixteen, scarcely more than one-sixth, have their direction recorded; and the descriptions of most of them are excessively meagre, and in some cases even unintelligible.

Of the peninsular earthquakes, records are given from the earliest years of the eleventh century down to 1844. The total number recorded is two hundred and twenty; taking these by seasons, as before, and omitting nineteen, of which only the annual date is given, we have for—

		Relative numbers.
Winter,	55	1.09
Spring,	41	0.82
Summer,	46	0.91
Autumn,	59	1.17

and taking, as before, the monthly mean as unity, the relative value

* The numbers given above are not the same as those given by M. Perrey in his tables, because I have embodied the additional information contained in his supplement.

† Bulletin de l' Acad. Roy. de Belgium, 1848.

for the seasons would be as shown above; or grouping the seasons, we would have for the six months from October to March, one hundred and fourteen; from April to September, eighty-seven, numbers which are also very nearly in the ratio of 4 : 3, as the author had obtained before from the rest of Europe. For France proper, the ratio was found to be as 3 : 2. Discussing the shocks, as regarding the direction in which the movement took place, he gives the relative numbers for each direction, and deduces from these the mean resultant direction of the motions for the Iberian peninsula to be east, 31° 56′ south.

M. Perrey very justly remarks, that on these results no great reliance can be placed; and points out very strongly the necessity of more careful observation, not only of the shocks themselves, but of the numerous phenomena accompanying them, thermometric, barometric, or meteorological, &c. In fact, what first and most forcibly arrests the attention in looking over the notices which M. Perrey has, with such labour and care, brought together from all the scattered records at his disposal, is the total absence in most cases of any notice of those very elements in the observations, which are essential to a proper study of the facts. I have already noticed the very small number in which even the direction of the movement is given; but this is not all—we have no record of the amount of this motion—no trace of the variation in this amount, if any—no notice of whether any permanent alteration in physical features of the district resulted—in few cases even a notice of the time of occurrence. It was, perhaps, scarcely to be expected that in the earlier ages such accurate accounts should be given, as would suffice for the present demands of science; but the same absence of any useful observation arrests our attention in looking over the records for 1847, and almost in as great a degree as in those for the tenth and eleventh centuries. We become—as we study such meagre accounts, in many cases given by persons perfectly incapable, from want of proper knowledge, or from the exaggerations of terms, to record with accuracy even what they may have observed, or to notice the facts which are essential to the correct knowledge of the cause of these striking phenomena—we become, I say, more and more convinced of the absolute necessity for adopting some well devised scheme of self-registering instruments to record the principal points connected with such phenomena; and we cannot but refer with great regret to the

somewhat extraordinary and unusual withdrawal by the British Association, or rather by the Committee of Recommendations of that body, of a grant which they had sanctioned during the previous year for the preparation and establishment of such instruments. I trust, however, that our last President, Mr. Mallet, who has already thrown so much light on the question of earthquake action, will still be enabled to carry out his ingenious scheme for such instruments.

But slight as is the scientific value of results deduced from such imperfect premises, as those which M. Perrey has found himself obliged to use, he has contributed essentially to the advance of knowledge on such subjects by the summary he has given. And his numerical results, drawn from instances so great in number, and extending over so large an area, and possessing such a regularity and constancy in their ratio, do seem to authorize a conclusion, that the circumstances of surface temperature, as shown by the variation of seasons, have some influence in the production of, or in affecting the causes tending to produce, such phenomena. And are we not by this fact almost unconsciously led to trace some new intimate connexion between the exhibition of such forces, and of volcanic action in general, and the great pervading magnetism of the earth. And is it too fanciful to suppose, that here, too, a new link in the chain, which so closely unites the great cosmical forces, may be rivetted, and that heat and electricity shall be found reciprocally to produce and to result from earthquake motion, or what we call earthquake motion; and that the laws which are known to regulate the direction of magnetic currents, may prove the key to a knowledge of the laws which have controlled the direction of volcanic forces on the earth's surface?

As bearing on volcanic action proper, we have obtained, during the past year, in Dr. Daubeny's second edition of his history of volcanoes, the most complete and perfect synopsis of facts, and the best guide for the student desirous of obtaining a knowledge of these interesting and intricate phenomena. Dr. Daubeny has, during the time, now some twenty years, which has elapsed since the publication of his first edition, seen no reason to alter his views as to the cause of volcanic action; and he still strongly and ably supports the so-called chemical theory. His work, however, is much more valuable as a summary of facts connected with the history of volcanoes.

Dr. Daubeny, incidentally in his treatise, has put forward a new

method of accounting for the long disputed question of the dolomization of certain limestones in the neighbourhood of igneous rocks. After alluding to the views often propounded, as to these igneous rocks being the source from whence the magnesia has been derived, he points to the many known and described cases in which peculiar ingredients have been determined to particular portions of the mass, and molecular changes have taken place in a rock without actual fusion; and asks, "May we not suppose, then, this same segregation of parts to take place in limestone rocks likewise? and may not the magnesia, previously disseminated through an extensive formation, be determined to particular layers, during the long continuance of a heat inferior to that which would be required to fuse the limestone, or to obliterate the traces of organization present in it? If so," he continues, "the existence of dolomites may be connected with the presence of an igneous rock without deriving its magnesian constituents from the latter source, and possibly the higher temperature of those portions of the limestone, which lay nearest to the source of heat may, by enhancing the affinity subsisting between the carbonate of lime and carbonate of magnesia, favour the formation of dolomite in those parts more particularly."* He thus looks on dolomization as only a peculiar case of metamorphism.

In connexion with this subject—one which has already received considerable illustration by the valuable analyses by our member, Dr. Apjohn, published in our journal—I would refer to a short, but interesting memoir on the geology of the island of Bute,† by another member of our Society, Mr. James Bryce, jun., in which, after a clear description of the general structure of the island, and a notice of some of the more remarkable points, he details the phenomena which occur at the contact of greenstone and limestone, where a dyke of the former traverses the limestone at Kilchattan. "Its direction," Mr. Bryce says, "is very nearly that of the dip, and the effects are well seen at the eastern side of the quarry. Along the plane of contact, the limestone is altered to the state of a granular saccharine marble, which, on the application of a slight pressure, crumbles into a fine powder. This is suceeeded by a hard crystalline marble; the crystals appearing in distinct plates. Between this and

* Daubeny on Volcanoes, second edition, page 708-709.
† Proc. Phil. Soc., Glasgow.

the last (? first) change, which is one of simple induration, there are many gradations." He proceeds to state, that similar effects are common, and notices the occurrence of magnesia under such circumstances, the simple carbonate of lime of the unaltered limestone becoming the double carbonate of lime and magnesia. And referring to the entertained views of geologists on this point, he states the results of an analysis of two specimens, one of the saccharine marble in contact with the dyke, the other of the unaltered limestone. The remarkable result was, by a rough analysis, that the unaltered limestone contained about thirty-four per cent. of magnesia, but the altered rock had not three per cent; while the presence of a silicate, probably silicate of magnesia, was indicated by the gelatinous paste of silica, obtained on treating the powdered rock with hydrochloric acid. Mr. Bryce asks, then, what has become of the magnesia? Has it been driven off by the heat to which the limestone has been exposed, and refers to the statements of Dr. Apjohn, which point out that this could in all probability not be the case; for a much lower heat than would be sufficient to expel the magnesia, would cause the silica to enter into composition with it, and form a silicate. Mr. Bryce has promised a complete series of analyses of the limestones, both altered and unaltered, of Bute, for the results of which we look forward anxiously.

But, however important the influence of igneous rocks may be in some local cases of dolomization, the numerous instances in this country and elsewhere, where we find thick and *continuous* beds of dolomitic limestone associated with, and regularly interpolated among other beds of simple carbonate of lime, totally preclude the possibility of applying such theories to explain their production. We might quote here the words of our colleague, Dr. Apjohn, read so long since as 1838, when—in alluding to the theory proposed by Dr. Scouler at that time, that the magnesian character of such masses was caused by the infiltration of magnesia dissolved in water charged with carbonic acid—he says, "I would merely suggest, as an extension of this hypothesis, that as many limestones contain a small quantity of magnesia, their conversion into dolomites may sometimes be accomplished, *not by the addition to them of magnesia, but by the removal of carbonate of lime.*"* The importance of a

* Jour. Geol. Soc., Dublin, Vol. I. page 375, &c.

careful examination of such rocks by analysis is evident from the unexpected results obtained by Mr. Bryce.*

M. De Beaumont in 1837, in a remarkably interesting notice on the formation of Anhydrite, gypsum, and dolomite,† pointed out some of the results, as regarded volume which would ensue from the supposed change of the simple carbonate into the double carbonate of lime and magnesia. Taking the equivalent of carbonate of lime as 632, and of carbonate of magnesia as 535*; and supposing the dolomite represented by the formula $\left.\begin{matrix}\frac{1}{2}\dot{C}a\\ \frac{1}{2}\dot{M}g\end{matrix}\right\}\ddot{C}$, we will see that any cubic contents of limestone thus altered, will be reduced in bulk in proportion to these numbers, but will have the increased density of the mixed salt (2.88,) this decrease in bulk being in the ratio of 1000 to 882, or about twelve per cent. of the total volume of the rock so altered. And M. De Beaumont pointed out the important bearing of this consideration, as explaining the cavernous structure common in dolomitic limestones.

These notes of De Beaumont have led M. A. De Morlot, at Vienna, actually to measure the proportion between the cavities in such rocks and the total volume. He took an average specimen of the grey crystalline dolomites of the southern Alps, and calculated carefully the volume of all the spaces, as compared with the total volume of the specimen; the proportion was found to be 12.9 to the 100—a result remarkably consonant with the theoretical result of De Beaumont, and quite within the limits of error, which we would naturally suppose should result from the employment of a single specimen of such small size, as compared with the great masses it was taken to represent. Now the fact of many corals being thus found in the state of cavernous dolomite, although preserving all their organic forms, shows clearly, that the peculiar character and composition is the result of a change which has taken place subsequently to their fossilization, and therefore, that the atoms of lime, replaced by the magnesia, have been removed and disappeared. What, then, have been the phenomena of this alteration,

* While speaking of dolomites, we would take the opportunity of referring to an elaborate history of dolomite, considered mineralogically, by M. Fournet, published in the Annales de la Soc. D'Agric, Lyons.

† Bull. de la Soc. Geol. France, Tom. VIII. page 177.

and what the chemical reaction? Haidinger, who has long studied these facts, having noticed them in the Transactions of the Royal Society of Edinburgh, in 1827, has been led, by his examination of the phenomena, and the remarkable connexion which frequently exists between gypsum and dolomite, to suspect that the magnesia had been brought in the state of sulphate of magnesia, a salt very common, abundant in some mineral waters, and even in the waters of the ocean; that this sulphate, in decomposing, had reacted on the limestone, so as to alter it into dolomite, by producing a double decomposition, resulting in carbonate of magnesia and sulphate of lime. We know, however, that an opposite decomposition takes place, and that sulphate of lime in solution, filtered through dolomite in powder, for a sufficient length of time, changes it into carbonate of lime, and forms sulphate of magnesia. Now Haidinger has observed the efflorescence of sulphate of magnesia in the quarries of gypsum. He noticed that the *Rauchwacke* was the result of a change of dolomite into carbonate of lime, by a gypseous solution, accompanied with a formation of sulphate of magnesia; and studying the peculiar relations under which the hydrated oxide of iron occurs, he is clearly of opinion, that this peculiar chemical reaction, the cause of what M. De Morlot calls *dedolomization,* has only taken place under small pressure, and at a low temperature, as in the laboratory. But on the other hand, taking the peculiar circumstances of other beds of dolomite into account, Haidinger was equally led to suspect, that although, as at ordinary temperatures, and under the ordinary atmospheric pressure, the sulphate of lime (gypsum) will decompose dolomite, so as to form carbonate of lime, and sulphate of magnesia, still under a considerable pressure, and at a higher temperature, just the opposite action would take place, and that then sulphate of magnesia would decompose limestone, and form dolomite and sulphate of lime. Having no index to the temperature which had existed at the time of the formation of these dolomites, he estimated, from the acknowledged increase of temperature as we descend, and the probable thickness of the beds, that a temperature of about 200°, corresponding to a pressure of about fifteen atmospheres, would be sufficient. Then mixing the atomic proportions of sulphate of magnesia and carbonate of lime, he subjected them to this temperature and pressure, (in a gun barrel) and found the double decomposition took place completely, and the double carbonate of lime and magnesia,

and the sulphate of lime formed.* These results are undoubtedly of great value; and it is not improbable that from the facts first stated by Elie De Beaumont, the presence or absence of a cavernous structure in a dolomitic limestone, may tend to a knowledge of the circumstances under which it was formed; while a consideration of Haidinger's results, in connexion with the peculiar relations of the beds or masses, may determine the conditions, as to temperature and pressure, under which this alteration has taken place.

I have dwelt much longer on this subject, than I otherwise should, from the interest which it possesses to the student of Irish geology, whose researches will make him acquainted with magnesian limestones of every kind, and occurring in every possible variety of position.

Other classes of alterations in the mineral structure of rocks have received attention, and have been elucidated by several observers during the year. M. Delesse has published in detail,* a continuation of his valuable memoir on the mineralogical and chemical constitution of the rocks of the Vosges, in which he describes, with great accuracy and skill, the composition and character of the Ternuay porphyry; having devoted the former portion of his memoirs to the porphyries of Belfahy and other points, and pointed out the great importance of studying chemically and mineralogically the unstratified rocks, and the mechanical deposits in connexion with them.

With this view, M. Délesse has examined the several constituent minerals of the porphyries, carefully separating each from the mass, and also the mass of the rocks in which they occur. And in the continuation of his memoir published last autumn, he follows up similar enquiries with respect to the porphyry of Ternuay. This had previously been classed by all geologists as a common variety of porphyry or of diorite, excepting by Mr. Cordier, who had recognized its distinctness, and given to it the name of Ophitone. Felspar of a greenish or slightly blue tint, having a more fatty lustre than ordinary felspar, forms the paste of this porphyry. It decomposes on the surface with a red tint, and forms a kaolin, as does the Belfahy porphyry. M. Delesse says it is remarkable that the felspars most poor in silica, (such as labrador, anorthite, &c.) and those which are

* A. De Morlot, Sur le dolomie, Bull. Soc. Geol. France, 1848, page 243, Haidinger, Naturwiss: Abhand.

† Annales des Mines, Tom. XII. part 5, page 283.

attacked by acids, resist this change into kaolin; while on the contrary, the orthose, albite, and andesite, varieties, which are rich in silica, and are very slightly attacked by acids, change readily. The author describes at length the physical characters of this mineral, and its chemical composition, action before the blowpipe, &c. &c.

During the process of these analyses, finding constantly an amount of loss, he was led to suspect that this felspar contained a certain marked quantity of water of combination; and uniting this fact with others which he had previously pointed out, he concludes, that spite of its easy volatilization, water plays an important part in some felspars and rocks, usually considered of igneous origin; and that although this may appear paradoxical at first, it is easy to account for it, by supposing sufficient pressure; besides the fact of the presence of water is not in reality much more extraordinary than the presence of potash or soda in the same minerals or rocks, since the hydrates of these bases would be volatilized at a much lower heat, than would reduce the rocks to a fluid state. He shows that when water enters into combination with these felspars, it gives to them peculiar characters. They have a fatty lustre, and waxy fracture; the specific gravity is greater than that of the varieties which do not contain water; they have ordinarily a green colour, which, although never observed excepting when oxyde of iron or manganese is present, is still clearer, richer, and more beautiful, in proportion as the water of the combination increases.

Now all these felspars are similar crystallographically, only presenting some slight differences in the facility of cleavage, and are therefore isomorphic; but isomorphic minerals can be represented by the same general formula, and this, therefore, ought to be the case for felspars. Our knowledge of the laws of polymeric isomorphism is too slight as yet to admit of this; but if we grant the remarkable hypotheses of Dr. Scheerer, as to the mode of substitution of water as a base, we arrive at results of great simplicity. In this way the analyses of the mineral in question would give the proportions of oxygen in the bases as in the ratio of 1 : 3 : 5—a proportion which no known felspar up to that time had exhibited, and comparing it with labradorite and anorthite, it would appear to make a middle term, and fill up the gap.

To this variety M. Delesse gives the name of Vosgite, from the mountains in which it occurs.

In another and distinct notice of the orbicular diorite of Corsica,* the same author states that the felspar in it has a specific gravity of 2.737. nearly equal to that of labradorite and anorthite in general, but less than that of Ternuay: it is crystallized in the sixth system. A careful analysis showed that it approached in character to Vosgite, but contained three parts less lime, much less alcali, and but little water of combination; to this small amount of water is its low specific gravity to be attributed. The proportions of oxygen in the monatomic bases is, however, as 1 : 3 : 5: the same ratio as in Vosgite, of which this mineral is only a variety; taking the general formula, therefore, we have for these felspars, the following:—

Labradorite,	$1 : 3 : 6\ r\,Si^3 + Al^3\,Si^3$
Vosgite,	$1 : 3 : 5\ r\,Si^3 + Al^3\,Si^3$
Anorthite,	$1 : 3 : 4\ r\,Si^2 + Al^3\,Si^3$

Reverting to his memoir on the Vosges rocks, we find that he has examined the augite, which forms the other principal ingredient in the porphyry, with equal care, and shown that it also contains water of combination to the amount of 2.75 per cent., and that the clearness of its green colour varies in proportion to this amount of water. Other minerals, which are only occasionally present, are noticed also, as iron pyrites, magnetic iron, quartz, epidote, &c.

Having thus examined in detail the constituent minerals, the mass of the rock was subjected to equally careful analysis and examination, and its several marked varieties described. The loss by heat of these is given; and however the external lithological character varied, it is remarkable, that the amount of this loss scarcely varied at all, giving an average of 3.0 per cent. After discussing some methods of obtaining the general density of the mass, and from this a knowledge of the relative proportions of the several constituents, and then to calculate "from this" the elementary composition of the mass, he finds that this porphyry of Ternuay, when well characterized, contains an amount of silica equal to that of the felspar and augite, which form its constituents, but that it has less of alumina, less of alcali, and generally less of water than the felspar alone, but more of protoxide of iron, of lime, and magnesia.

* Comptes Rendus, October, 1848, page 411.

The average composition of the normal type of the rock is—

Silica	49
Alumina	24
Oxyde of Iron and Manganese	3
Lime	8
Magnesia	6
Soda	4
Potash	3
Water	3

In his notice of the orbicular diorite of Corsica* he states, that calculating the atomic volumes of felspar (vosgite) and hornblende which form this rock, he finds that these volumes have to each other the simple proportion of 4 : 3, and that this law appears to apply to all varieties of diorite, melaphyre, pyroxenic porphyries, euphotides, &c., and in general to all rocks of an igneous origin composed of two elements, of which one is crystalline felspar of the sixth system, the other a silicate of iron and magnesia of the fifth system, such as amphibole, uralite, pyroxene, augite, hypersthene, diallage.

Having thus completed his analyses of the igneous rocks, he proceeds to discuss the changes which have taken place in the adjoining schists which have been elevated by them. This metamorphism is only on a small scale, not extending more than three yards from the mass; but taking four specimens at different distances, the furthest from the igneous mass representing the unaltered condition of the schists, and that next to the mass, the most altered, he finds by careful analysis that the density of the rock increases as we approach the igneous rock from 2.743 to 2.852—that the amount of lime also increases; and he shows most clearly, that this results from an actual transfer of a portion of the elements of the porphyry into the slates, by which, in these slates, crystals of vosgite are formed, crystals of a mineral which could not otherwise have been formed in the slates, as the elements which enter into its combination do not therein exist.

The porphyry thus so carefully described by M. Delesse, is worked for ornamental purposes, and has been selected to form the base of the monument to the Emperor, in the Hotel des Invalides.

On the same district—one rendered classical in the history of

* Comptes Rendus, October, 1848, page 411.

geology by the labours of many able investigators, but the rich stores of which are not even yet exhausted—we have a most interesting digest of his observations, by M. Fournet.* Directing his examination only to the eruptive rocks and the metamorphic phenomena, he scarcely enters on the question of the succession of the sedimentary rocks. The eruptive rocks consist of granite, syenite, porphyry, diorite, &c., all of which are well described. The metamorphic phenomena are then passed in review. The principal results of the action of the granite is the production of micaceous schists; as a subordinate effect the change of schist into schistose diorite, or greenstone, of which there are stated to be very clear examples—the development of crystals of sahlite, amphibole, mica, sphene, &c., and, remarkably enough, the production of noble serpentine in the middle of the calcareous beds, which M. Fournet states is also clearly a metamorphic result. The porphyries have hardened, rendered prismatic, fused or semifused the slates, which pass into hard compact or granular pastes of a greenish colour and euritic, generally having small crystals of felspar. Many of these distinct porphyries are described, and the reasons fully stated for supposing them to be the result of alterations in the bedded rocks, and not to be eruptive. M. Thuria had previously suggested that many of these porphyries, which were jointed, and had a certain amount of schistose structure, were in reality eruptive, having been poured out cotemporaneously with the deposition of the mechanical rocks; but this notion M. Fournet combats. He also describes the melaphyre rocks of Oberstein, so famous for their agates, and enters fully into the question of their origin.

Subsequently taking up the question of alteration generally, and pointing out the reciprocal or mutual action which has taken place in most such cases of alteration, he distinguishes the two results. Thus retaining the general term metamorphism, as applicable indifferently to modification of the igneous or of the sedimentary rocks, he proposes to apply the term *exomorphism* to those particular cases in which the sedimentary rock has been changed, or when the alteration has been *outside* the source of change; and the term *endomorphism* to those cases in which alteration has taken place within the rock itself; and thus he would speak of endomorphic and exomorphic rocks, &c.

* Annales de la Soc. d'Agric de Lyons, Tom. X.

Fournet's paper, although on the same district, differs most materially from that of M. Delesse, to which I have before referred, in the absence of those accurate and detailed numerical results which form the great value of the latter; but it is characterized by broader and more general views, and is of great interest to the Irish geologist, as bearing on alterations, most of which are perfectly paralleled in this immediate neighbourhood; although we cannot agree with him in several of his conclusions, as for instance, his rejection of Thuria's opinion, that many of the porphyritic rocks of that district may have been cotemporaneous with the sedimentary, a fact which we see so abundantly illustrated in our own land: still it forms a valuable and important contribution to our knowledge.

I have given a more detailed analysis of M. Delesse's short paper, than perhaps the limits of this address would fairly permit; but I have done so, because it is one of the few papers to which we can point, in which there is that union of accurate analysis, with careful examination in the field, so entirely requisite for the full or trustworthy examination of such subjects. During the past year, in a communication which I myself laid before this Society, touching on the question of metamorphosis, as exhibited in the county of Wicklow, I ventured to express opinions very similar to those of M. Delesse, regarding the actual transfer of some of the elements of the igneous rock—in this case granite—into the slates adjoining; and I also gave you several instances of changes similar to those alluded to by M. Fournet, in which we have largely crystalline greenstones, unquestionably the result of an alteration induced in originally laminated schists; and when some analyses at present in progress shall have been completed, I hope to find results very similar to those which he has given. I would also point to the almost total absence of such examinations in these countries, as an additional proof of what I have frequently insisted on, viz., that too great tendency to overrate the importance of fossil remains, and in consequence to neglect the study of those great masses in which no trace of organized life exists. As far as fossiliferous rocks are concerned, unquestionably the importance of such evidence as the remains of animals entombed in them afford, if rightly interpreted, can scarcely be overrated; but it must be borne in mind, that these rocks form only a portion, nay only a small portion, of the earth's crust, and that, therefore, for all the remaining portions such researches are useless. I think it an

error which cannot be too strongly or too frequently protested against, the allowing a student to suppose that the mere knowledge of the external aspect of some ten or twelve minerals will suffice him for his geological pursuits. And although, as a necessary result of the accumulation of knowledge, a division of labour has ensued, and many have devoted themselves to one portion of such enquiries and many to others, still all are so intimately linked, that success in one cannot be looked for, or at least commanded, without something more than a mere general or superficial acquaintance with the others. But I have already, in the remarks with which, at the request of your Council, I opened the present session of the Society, endeavoured to impress on you the injurious effect, which a partial cultivation of any portion of our subject has produced, and is calculated to produce.

The Society will remember perfectly the very interesting communication of Dr. Apjohn, in 1847, on a Hyalite from Mexico, in which he found much less water than in the described species, and pointed out the remarkable optical properties possessed by it. The researches of M. Damour* on the siliceous incrustations of the Geysers, have an immediate connexion with the same subject. Following up his enquiries on the thermal silici-ferous waters of Iceland, he has submitted to analysis the siliceous matter deposited by these waters; and which he denotes by the general name Geyserite. This substance occurs in concretionary masses, white, greyish-white, or occasionally tinged with red. Its structure is cellular, sometimes scaly; in parts it is quite transparent, and has a vitreous fracture. Some few specimens present very beautiful opalescent tints of blue and green, but only retain this property while moist; if exposed to dry air, the opalescent portion falls to powder. Experiments showed that the silica was in some molecular condition which rendered it easily attacked by alcaline mixtures, and besides, as it dissolved in carbonate of soda much more easily after calcination than before, it appeared that the expulsion of the water modified the molecular condition, and consequently that a portion of the water was in a state of combination. Exposed for a long time to an atmosphere of dry air, it loses more than two-thirds of its water; while, on the other hand, if exposed in an atmosphere saturated with

* Bull. de la Soc., Geol. France, 7th February, 1848.

moisture, it absorbs a sensible quantity of water. A portion of the mineral previously calcined and powdered, was heated to boiling for five hours, in a concentrated solution of carbonate of soda and sulphur in excess; the liquor became coloured of a yellowish brown tint, with a slight smell of sulphurous acid; at a temperature of 70° cent: the liquor remained transparent, but became milky on cooling, and the silica was thrown down in plates; on heating again, the transparency was restored, and these phenomena were repeated, as often as the temperature was raised or disminished. It appeared, then, that the presence of sulphur in excess determined the separation of silica from an alcaline solution, so long as the temperature was under 70° cent: A careful analysis showed the presence of minute portions of lime, alumina, and soda, and traces of potash in the substance. And M. Damour thinks that this discovery of the presence of an alkali may afford a clue to the knowledge of the origin of several deposits of amorphous quartz, its presence serving to point to an origin analogous to that which the Geysers now present. Viewing, then, Geyserite as an hydrate of silica, he was led to comparative analyses of the minerals of the same group, such as opals, resinites, and hyalites. The results are all carefully detailed, and he finds, that in addition to the three known artificial hydrates, there are four natural hydrates.

Opal of Mexico, Geyserite,	$HO + 3\,SiO_3$
Opal of Hungary,	$HO + 2\,SiO_3$
"Silex resinite" of Mexico	$HO + 4\,SiO_3$
Hyalite	$HO + 6\,SiO_3$

To these we must add the hyalite of Mexico, described by Dr. Apjohn. The opal of Mexico, and the Geyserite, were found to be identical in composition, and this opal was also very hygroscopic, a specimen which, when freshly cut, was quite transparent, becoming soon milky and dull.

These results of M. Damour are peculiarly interesting in connexion with the researches of Bunsen, Descloizeau, &c., and are another of the many important results which have sprung from the scientific expedition to Iceland. It is to be greatly regretted, that M. Damour did not submit his specimens to careful optical examination, so that their internal structure might be compared with that described by Dr. Apjohn.

In the first volume of the publications of the Cavendish Society, we have, during the past year, had a translation given of a most important memoir from the pen of Professor Bunsen of Marburg, which originally appeared in Liebig's Annalen: bd. lxii. 1847. Full, accurate and complete, as has been every thing emanating from Professor Bunsen, this memoir, "On the pseudo volcanic phenomena of Iceland," recommends itself particularly to geologists, by the important bearing which many of Bunsen's conclusions have in explaining some interesting, but hitherto not fully understood, facts in geological history. In strict accordance with the principle on which I have intended to act in selecting matters for observation, namely, to confine myself exclusively to communications published during the past year, I should omit any notice of this valuable paper; but as it has only become known to the English reader within that time, I may very briefly allude to some points in it.

One of these, of some interest, is the conclusion to which Professor Bunsen has come, with regard to the origin of the Muriate of Ammonia, which is so common a product in volcanic countries. Contrary to the views of other writers, he believes that ammonia, nitrogen and their compounds, although so frequent an accompaniment of volcanic action, "belong originally to the atmosphere, or to organic nature," "and are foreign to the actual source of plutonic activity." He supposes that the sal ammonia, is due to the action of the flows of heated lava, upon vegetable substances, with which they have come into contact at the earth's surface, and gives a very strong confirmation of this view in the circumstances accompanying the flow from Hekla in 1846. Here the lower portion of the lava stream was, for some months after the eruption, studded over with little fumeroles, in which an amazingly large quantity of crystallized muriate of ammonia was found; but this formation of sal ammonia was entirely confined to that portion of the lava flow which had passed over meadow land; higher up and nearer the summit, where vegetation ceased, the formation of this salt equally ceased, the large fumeroles there yielding only sulphur, muriatic, and sulphurous acids, but no trace of ammonia. But by much the most important portion of the memoir, relates to the remarkable phenomena of decomposition, which the rocks exhibit under the influence of the acid gases and thermal waters of the volcanic district. The effect of sulphurous acid on the prevailing rock of the

district, a palagonite* tuff is traced out: the resulting formation of sulphuric acid and of sulphates; the oxide of iron being originally dissolved, as a sulphate of the protoxide; and these acid solutions being neutralized by their further passage through the rock, this oxide of iron is again thrown down as hydrated peroxide, or sesquioxide. "The decomposed palagonite is thus converted into alternate and irregularly penetrating beds of white ferruginous and coloured ferruginous fumerole clay," (p. 334.) Professor Bunsen remarks, that one is astonished at observing the great similarity existing between the external phenomena of those metamorphic depositions of clay, still in the act of formation, and certain structures of the *keuper* formation. A similar action takes place with regard to the sulphates of alumina, the formation of gypsum being a main product. And here, again, it is said, "we can scarcely avoid the conviction, that the origin of a portion of the vast deposits of gypsum, which so frequently characterize the marly argillaceous strata of the later floetz series, and in which the total absence of calcareous conchylia points to the action of acid vapours, is due to a chemically identical, but, perhaps, geologically different action; and Professor Bunsen

* Palagonite (from Palagonia) is the name given by Baron Waltershausen to a mineral noticed by him as abundant in Sicily, and of which the composition is as follows:—

Silica,	37.417
Sesqui-oxide of Iron,	14.175
Alumina,	11.165
Lime,	8.766
Magnesia,	6.036
Potash,	0.685
Soda,	0.652
Water,	17.152
Insoluble residue	4.108
	100.156

leading to the formala-

$$\left.\begin{matrix}\dot{Mg}_3\\ \dot{Ca}_3\\ \dot{K}_3\\ \dot{Na}^3\end{matrix}\right\}\dddot{Si}_2 + 2\left\{\begin{matrix}\dddot{Fe}\\ \dddot{Al}\end{matrix}\right\}\dddot{Si} + \dot{H}$$

or in general terms—

$$\dot{R}_3\ \dddot{Si} + 2\ \dddot{R}\ \dddot{Si} + 9\ H$$

alludes to the value of a careful investigation of these deposits, with a special reference to their natural relations. The important difference in the results depending on differences in the gases evolved is also pointed out; thus when sulphuretted hydrogen abounds, iron pyrites is found in large quantity;* where sulphurous acid, as we have already stated, alum, gypsum, &c., result. The phenomena of the Geysers having been passed in review, Professor Bunsen concludes his memoir by some general considerations, as connected with the relation of the clinkstone, and older trap, and the tuff, and the remarkable occurrence in the latter of numerous hydrated compounds.

We rejoice to know that this and his other papers are only slight sketches, preliminary to the more full and detailed account of his researches, which Professor Bunsen has promised, and for which we look forward with anticipation of most valuable results. There are few fields more perfectly adapted for the study in detail of such phenomena than Iceland, and there are few departments of our science in which less progress has been made than in chemical geology. Professor Bunsen has well remarked, that the attention of geologists has hitherto been almost exclusively directed to the metamorphism of rocks by the action of fire, while the transformations effected by gas and water must have played a scarcely less important part. It may, I think, be fairly doubted, whether masses so little capable of conducting heat, as we know many of the older rocks are, could have been modified to the extent they have, unless we admit the action of water to have been largely concerned in such changes, partly as a conductor of heat, partly as a source of change itself.†

M. Delesse, to whose interesting memoir on the Vosges rocks I have already alluded, has more recently given an equally detailed and careful examination of the Protogene of the Alps‡, and of each of its constituent minerals. He concludes, that protogene is a well characterized granitic rock, of which the principal elements are quartz—two distinct felspars, one the orthose, the other the oligoclase

* For some valuable remarks on the geological bearing of this fact, see the original memoir. Cavendish Society, Vol. I. page 340-341.

† In the quotations from Professor Bunsen's paper, I have used the translation issued by the Cavendish Society in their first volume, 1848.

‡ Annales de Chimie, January, 1849, page 114.

variety; a biaxial mica very rich in iron, and a talc: differing from ordinary granites, having two felspars, by the composition of its mica and by the presence of talc. The analyses of each of these minerals is detailed, as well as that of the several marked varieties of the mass, by which it appears to differ from the mean composition of granite, (of which the author previously published numerous analyses,) only in having a little more oxyde of iron, and magnesia. Among all the numerous varieties of protogene, two distinct classes may be recognized, one possessing a distinctly granitic structure, in which the crystallization is well marked; the other having a schistose structure, in which the crystallization is less distinct, and even confused. These mineralogical differences correspond to a simple difference in chemical composition, the most highly crystallized varieties possessing a larger amount of silica than the others; and the distinctness of the crystallization varying with this variation in the amount of silica. Those varieties in which this element is found in smallest quantity, occur near the boundaries of the formation, as had been previously noticed with regard to granites also.

I would suggest the extreme importance, and indeed the necessity, of a very careful examination of all the circumstances attendant on such phenomena, before attempting to explain this fact of a diminution of silica, as we proceed from the centre of the mass towards its outskirts. So many and successive changes and variations have taken place in such rocks, that it will frequently be exceedingly difficult to render intelligible the causes which have successively produced the result we now see. Towards such an end, however, the contribution of every such truth as those M. Delesse has published, tends most essentially, and it is, in fact, only by such accurate chemical analyses, that we can ever hope to throw light on the phenomena. Among the results announced by M. Delesse, we should not omit to mention, that he finds the ordinary brownish coloured quartz of the protogene (smoke-quartz,) to derive its colour from the presence of organic matter easily volatilized without residue, and which disappears entirely after a slight calcination, the quartz becoming white and transparent, and only losing in weight $\frac{12}{1000}$ Whence was this organic matter derived? If not in these plutonic rocks, where can we hope for a truly azoic mass? These are questions which immediately rise before the mind, and the facts point to a reaction on the mass of granite rocks, of great interest in considering its origin and mode of formation. But I can only allude to these points.

Passing now, from these applications of chemical investigation to the study of the mineralogical structure of modifications of rocks, to the consideration of simple minerals, we can refer to several valuable additions to our knowledge of the laws which govern their formation, during the past year. The question of Dimorphism has engaged the attention of Pasteur and Nickles. Pasteur has described some crystals of sulphur, artificially obtained from the sulphuret of Carbon, on which both the forms of this mineral, so well known to be dimorphic, were distinctly visible.*

Nickles† has established the dimorphism of zinc. Pure zinc, as stated by Noeggerath, crystallizes in hexagonal prisms. Zinc, antimony, and arsenic were, therefore, the only metals not belonging to the regular system. M. Nickles has, however, found pure zinc, prepared by Jacquelmain's process, to crystallize in pentagonal dodecahedrons, very similar to those of iron pyrites and grey cobalt, thus placing it in the regular system; while it is interesting, at the same time, to find that its dimorphism attaches it to a group of metals, to which, from its chemical properties, it should belong. The fact of tin being dimorphous was known by the researches of Miller and Frankenheim; and G. Rose has shown Palladium and Iridium to be isodimorphous. "We are therefore justified," says M. Nickles, "in anticipating that one day antimony and arsenic will also be found to be dimorphic, and thus subject to the common law, which would appear to place all the metals in the regular system."

M. Pasteur,‡ in a valuable paper "On Dimorphism" in general, gives a list of all known cases of dimorphism, and discusses each very fully. He finds, as the chief peculiarity common to all dimorphic substances, that one of the two forms which they present, is a limiting form, placed, as it were, at the point of separation of the two systems to which the dimorphic crystals belong. Of this many instances are given. From one of the forms you can, by the laws of simple derivation, arrive at the secondary faces which occur on the other form of crystal. From this, then, it follows that dimorphism can be almost predicted. As an instance, M. Pasteur states that prussiate of potass in the ordinary form, very nearly approaches to a right square prism, and that in all probability it will be found

* Annales de Chimie, Dec. 1848, Tom. XXIV. page 459.

† Do. do. Jan. 1848, page 37.

‡ Annales de Chimie, July, 1848, p. 267. Comptes Rendus, March 20th, 1848.

dimorphic, and if so, to be crystallized in this system. The two arrangements, or molecular equilibria, which correspond to the two forms, are equilibria, so closely related one to the other, (although belonging to two different systems, and subject to their general laws,) that they can pass one to the other. Dimorphic substances are, therefore, according to M. Pasteur, isomeric substances, in which the molecular arrangement is slightly different.

The same author has offered some curious remarks on the relation between crystalline form and chemical composition, and the cause of rotatory polarization; and reasoning from the remarkable phenomena presented by the tartrates and paratartrates, states that all polarizing crystals owe this property to the dissymmetry, or want of symmetry, of their molecules.*

In the volume of chemical reports and essays published by the Cavnedish Society, is an admirable resumè of the state of knowledge on isomorphism, and its modifications, which will prove interesting and valuable, as a summary of facts already established, both to the geologist and mineralogist. It is a translation of one of the chapters of Professor Otto's (of Brunswick) Chemistry.

Otto Volger has described some pseudmorphs of Fahlerz.† Damour has given the analysis, and Descloizeau has described the crystalline form of *Malakon*, a hydrosilicate of Zirconium.‡ Descloizeau has restored the name of Christianite§ to the lists of mineralogists, and applied it to a mineral belonging to the harmotome group. It had originally been applied to some crystals from Vesuvius, afterwards proved to be only Anorthite. The mineral now described from Iceland, where it occurs, forming druses in cavities of trap amygdaloid, along with Chabasie and Levyne, at the bay of Dyrefiord, is very similar to, and only a variety of, the lime-harmotome of Marburgh, which has hitherto been considered the same as the Phillipsite of Levy; but M. Descloizeau, after a full discussion of the published analyses, concludes that lime harmotome, and barytes harmotome, are not isomorphic, and that the lime harmotome of Marburgh is not the same species as the Phillipsite of Levy; and proposes, therefore, that the name Phillipsite should be restricted to the

* Comptes Rendus, 22nd May, 1848, page 535.
† Pogg: Annalen, 1848, bd. 5, page 25.
‡ Annales de Chimie, Sept. 1848, pp. 87—94.
§ Annales de Mines, tom. XII. page 5, liv.

minerals from Capo-di-bove, and Christianite applied to the harmotome of Marburgh and of Iceland.

The same author has also concluded, both from crystallographic form and chemical composition, that Gehlenite, (which was considered a variety of Humboldtilite,) is a distinct species.

Mr. Lawrence Smith has announced the discovery of two new species, on pitchblende, near Adrianople—one a double sulphate of lime and uranium, to which he has given the name of Medjidite; and the other, a carbonate of lime and uranium, called by Mr. Smith, Liebigite.*

Mendipite, one of our rarest minerals, has been recognized as occurring at Bilon, near Bonn.;† and to the researches of Mr. Townsend we are indebted for a knowledge of the occurrence of several minerals in the County of Donegal, which had not been previously noticed in Ireland, and of which he has presented specimens to our University Museum.

The tendency, however, of more careful research and improved analysis, has been rather to diminish the number of so-called mineral species; and we would refer with pleasure to the recent works of Dufrenoy, Naumann, &c., as exhibiting such results most clearly and satisfactorily. Rammelsberg has also given us another supplement to his most valuable Dictionary of the Chemistry of Mineralogy, in which the work is brought down to the year 1847.‡

We cannot pass from the subject of mineralogy and its important bearings, without referring to the most beautiful and valuable researches of Faraday and Plucker, on the crystalline polarity of Bismuth—researches which, in conjunction with Faraday's previous conclusions on diamagnetism, promise to work a great change in our knowledge of the cosmical forces, which have acted, and are acting, though unseen and unfelt, in producing the present forms of the solid matter around us. M. Delesse has also given some interesting re-

* Comptes Rendus, February 7th, 1848. Silliman's Journal, No. 15, May, 1848. page 336.

The formula of Medjidite is $\dddot{\mathrm{U}}\,\dddot{\mathrm{S}}\mathrm{i} + \dot{\mathrm{C}}\mathrm{a}\,\ddot{\mathrm{C}} + 15\,\dot{\mathrm{H}}$.

„ of Liebigite $\dddot{\mathrm{U}}\,\ddot{\mathrm{C}} + \dot{\mathrm{C}}\mathrm{a}\,\ddot{\mathrm{C}} + 20\,\dot{\mathrm{H}}$.

† Bull. Soc. Geol. France, 9th November, 1847.

‡ Rammelsberg: Handwörter buch des chemische theils des Mineralogie. Third Supplement, 1845—1847.

searches on the polarity of minerals and rocks;* and M. Pasteur, on the relation between crystalline form, chemical composition, and rotatory polarization in minerals,†

There is one other matter of very great interest, as bearing on the application of chemical discoveries, to the explanation of geological phenomena, to which I must refer in a few words. The influence of time in modifying or inducing chemical affinity, had already engaged the attention of several chemists. In considering this subject, our fellow-member, Mr. Sullivan, was led to imagine that the time in which a given chemical effect could be produced, might be influenced by a mechanical vibration of the bodies acted on; that is, by the communicating to the particles of the body motions, such as would allow them readily to assume a new arrangement. And on testing this idea, it was found to be fully borne out by experiment. The substances operated on were principally those whose atoms are held together very loosely, and which were very readily acted upon by heat, electricity, light, &c. In most of the cases tried, the changes observed were chemical; but in some, the changes were such as could only be discovered by an alteration of physical properties, especially by the action of polarized light. In fact, very slight mechanical action appears to alter the structure, as it were, of fluids as well as of solids. The only one of these experiments—the results of which have as yet been published—was the conversion of styrole into metastyrole. Hoffman and Blyth found that by heating the fluid to which they had given the name of styrole, to a temperature of 200°, cent. in a closed tube, it was converted into a vitreous mass, which they called metastyrole. Now Mr. Sullivan has found that the same effect was produced, by vibrating a tube full of it for thirty hours. The vibration was given by clock-work, which set a bow in motion.

Other experiments have since been tried, some of which, by the kindness of Mr. Sullivan, I can state. A mixture of protoxide of nickel, and chloride of lime, was partially converted into peroxide of nickel, and chloride of calcium. This frequently requires several weeks. Again: aldehyde is converted into metaldehyde.

A solution of oxalic acid mixed with a solution of chloride of gold, perchloride of platinum, or chloride of iridium, and ammonia, is de-

* Comptes Rendus, page 548, November, 1848.

† Ann. de Chimie, page 442, December, 1848.

composed with the evolution of carbonic acid. Boiling does not effect the same result, although the continued action of sun light does, (not, however, in Ireland.)

If the body obtained by the action of chlorine on light muriatic ether, and which has the formula of $C_4\ H_3\ Cl_2$, and which is not acted on by an alcholic solution of potash, be vibrated for several days, it will then be decomposed, by such a solution, into muriatic acid and some new compounds. In fact, it will be converted into the body of the same formula in the isomeric group, and which is obtained by the action of chlorine on olefiant gas, and which yields up its chlorine to potash. This is a peculiarly interesting experiment, and goes far to support the views of Laurent and Gerhardt, as to the substitution of hydrogen by chlorine.

Again: if oil of turpentine be kept for some time in contact with oil of vitriol, it will lose its power of causing a ray of light to turn to the left; but if vibrated for a considerable time, it will gradually resume its original power.

Although only just commenced, I think that the few cases I have stated will be more than sufficient to show that these ingenious experiments of Mr. Sullivan have opened up a new field of enquiry, which promise to yield a rich harvest of results, bearing most importantly on questions of chemical affinity, and, as will be evident, having a direct and immediate influence on the progress of mineralogical knowledge. Mr. Sullivan is extending these experiments, and I doubt not, that before the close of the year, he will have obtained new results of equal or greater interest than those I have been enabled to give.

Such, gentlemen, is a very brief summary of what has been made known during the past year in the several branches of our all-embracing subject. Limited, as our view necessarily has been, to such a short period of time—a period also in which less activity has been displayed in scientific pursuits than is wont, from the absorbing nature of the many political changes which have occurred—such a sketch became almost unavoidably a mere statement of facts, and not as we should prefer, were it possible, an elimination of principles. Still even such a dry detail of apparently isolated facts, becomes extremely useful, when we seek to advance the boundaries of our knowledge, or promote the steady progress of our science. If, therefore, the past year may not have added much to our acquaintance

with the higher and more general laws of our science, it *has* done much to facilitate that laborious accumulation of facts, or in other words, that knowledge of phenomena, on which, to be useful, any such advance must be based.

Indeed on reviewing the progress of knowledge, especially as regards the sciences of observation for some years, we might be almost tempted to declare, that its great feature was a tendency to minuteness of detail, rather than to largeness of view—a desire to sift with all possible accuracy the peculiarity of each individual case that presented itself, rather than to obtain from such observations a knowledge of the principles essential to the production of the phenomena, and therefore generally applicable under analogous, though not identical, conditions—to seek rather to become acquainted with the verbiage in which the ideas were clothed, than with the ideas themselves. Unquestionably before we can even attempt to comprehend those ideas, we must understand the language in which they are conveyed; but this knowledge once obtained, to continue its pursuit, is but to acquire a succession of words unsuggestive of any new combinations of thought, and unproductive of any useful result. No really useful, at least no extendedly useful, application of any scientific principle has ever been made, excepting after a patient and careful investigation of the laws by which it was regulated; and after some degree, at least, of completeness in the knowledge of those laws has been attained. In seeking, therefore, for any useful applications of our science, we seek not for instances of mere present or momentary utility, in which the knowledge acquired by the geologist may have been successfully applied to the immediate acquisition of increased produce, or wealth, or the promotion of the comforts, or the supply of the wants of society. The efforts of thought have a higher value than all this; and the additional energy which such researches give to the workings of intellect, forms as true and as sound a claim on our admiration and encouragement, as any means which they afford of applying the truths thus acquired to human uses.

But while we are perfectly satisfied that the lower consideration of how such studies may tend to increase man's wealth, never will, never can, lead to that patient, and cautious, and laborious preparation which must be undergone before any sound knowledge of the principles involved be attained, we are equally convinced, that once

attained, *it is the duty, it ought to be the pleasure,* of every one to whom any of this knowledge is given, to contribute in every way to diffuse the information thus acquired, and to point out, as far as in his power, every increased facility, and every additional means, which his science can suggest, to promote the happiness and the comfort of others.

In this point of view, some communications during the past year on the practical applications of geological principles, are not without their interest, even to a scientific society.

The value of geological knowledge in mining operations is now so generally admitted, that we need scarcely allude to the many important ways in which the scientific principles of the one throw light upon the other. Acknowledging this fact, M. Amedée Burat, already known as the author of an useful work on geology applied to mining,* has discussed the question of the continuity of metalliferous deposits in depth. This question is one of general interest, and perhaps even of special interest in this country, where the opinion very commonly prevails, that our metallic lodes diminish essentially in productiveness, as the depth from the surface increases. To determine, therefore, whether, *a priori*, such should be expected, though purely a geological question, is yet one having an essential practical bearing on the resources of this country. M. Burat, pointing out the principal localities in which new sources of metallic ores (excepting iron) have been found since 1815, and taking the return of the produce from these new sources, as compared with the whole produce, shows that the increase of production has taken place principally in the countries of mines already wrought, either by the extension of the existing works, or by re-opening mines previously abandoned. Now a considerable extension has taken place of these works *in depth*, and M. Burat proceeds to discuss the application of theoretical principles to such cases, seeking to prove the unsoundness of the prevailing notion of the decrease in productiveness, with the increase in depth, of metallic lodes. The cases cited by M. Burat, are valuable facts controverting this notion, but he appears to me to have overlooked some of the most essential conditions of his problem. It is a perfectly established fact admitted by all, that the nature of the rocks which form the walls or boundaries of a metallic vein,

* "Geologigie applique."

exercises a most important influence on the productiveness of the lode; so well acknowledged is this indeed, that the working miner can in most cases predict, with tolerable accuracy in any district with which he may be acquainted, the chances of a portion of the vein being productive or not from the nature of the rock adjoining, or what he calls the *country*. An instance well known of this may be cited from the Derbyshire lead veins, where the productiveness of the veins is at once reduced to almost nothing, when they pass through the *toadstone* of that country, (a rock which, in fact, derives its name from this circumstance, the word being a corruption of *todt stein*, dead or unproductive stone,) while the vein again becomes productive, as soon as it has passed beyond this influence. Another instance on the large scale might be given from Cardiganshire, where all the lodes are confined to a district in which the rocks have a peculiar lithological character, although belonging to the same series as those which cover a very large area beyond, but in which no lodes have been traced. Now, this fact M. Burat has altogether overlooked, although it appears to me perfectly essential for the correct solution of the question. In Derbyshire, for instance, the ore-bearing strata are well known, and below them no miner would think of sinking into the old red sandstone in search of lead; the vein may be there, nay, may even increase in width and importance, but the valuable contents of it will be absent. We may, therefore, fully grant to M. Burat, that the vein or fissures (subsequently filled in,) being the result of subterranean action are continuous in depth, without in the least granting that the metalliferous contents of that vein are equally continuous. The presence or absence of these ores being dependent on other conditions, the indefinite proposition that metalliferous deposits are continuous in depth, will not hold.

Besides the variations in the productions of a lode to which I have alluded, as dependent on changes in the mineral character of the enclosing rock, there are other variations even where the "*country*" remains the same, dependent on other causes with which we are not as yet fully acquainted. Thus, independently altogether of those "nips" or "squeezes" which every miner is familiar with, the section of any large mine will at once show that the productive portions of the lode form detached masses, which, viewed as to the position of their occurrence in the direction or length of the vein, observe in each mine a certain amount of regularity in their distri-

bution—that is, the extent or size of the productive portion as compared with the extent of the unproductive, observe in the main, a given ratio. Now, in the case we have supposed, viz.—when the enclosing rock continues the same in depth, and in length, I think we are justified in asserting that the same law of distribution of the productive portions of the lode will hold in depth, as is proved to hold in length; and that therefore in any given vertical sinking, we ought to anticipate certain alternations of richer and poorer portions of the lode. If this be the case, it is obvious that the occurrence of one of these poorer zones ought not by any means to discourage the further exploration of a mine, other circumstances being favourable.

We would, therefore, restrict the general proposition that "metalliferous deposits are continuous in depth," within certain limits; but if thus restricted, and expressed perhaps in this way, "that metallic lodes will continue to hold the average amount of ore at all depths, where the containing rock or 'country' continues the same," we believe that it may most unhesitatingly be admitted, and acted upon.

But the productiveness of a lode in ore, and its productiveness in profit derivable from the working of this ore, are two very distinct questions; and while from the principles I have laid down, it will be evident that to determine the probability of the former, is purely and essentially a question for a geologist, the latter must be decided on totally different and independent grounds. Here the situation of the mine, the command of economical power, the facility of drainage, transport of ores, &c., &c., and in no small degree, the skill and intelligence of the managers, all exercise a most important influence.*

I have dwelt on this subject as one which is of practical interest in Ireland, and for the determination of the general elements of which the progress of an accurate survey, such as that now being steadily carried on, will furnish all the necessary data.

To M. Riviere we are indebted for a sketch of the metalliferous deposits, especially of Blende and Galena, which occur in that

* A very striking instance of how the profitable working of a lode is dependent on totally different circumstances, from the productiveness of the lode in ore, may be cited in the case of the great quantities of *pure metallic copper*, found near Lake Superior; but the expense of the removal of which, as it had to be all cut with cold chisels, was so great, that this *pure metal* could not be brought into the market at the same price, as the metallic copper smelted from the poor ores of this country.

portion of the right bank of the Rhine, between Coblentz and Dusseldorf. The principal rock of the district is greywacke, more or less schistose: a few patches of tertiary rocks occur, and some igneous intrusions, principally of diorite. Some of the veins are of unusual size: there are two principal systems—1st, composed of quartz, blende, galena, &c., and traces of copper—the 2nd, of quartz, copper pyrites, grey copper (panabase,) and other minerals of copper. Of the 1st system, all the lodes have a general relation, and are nearly parallel, having a mean direction from E.N.E. to W.S.W. Their general direction corresponds with that of the rocks, and probably depends on the system of dislocations which have disturbed the district. The date of the lodes is well marked as posterior to that of the slate, but anterior to the formation of the anthracitiferous beds above, as these contain rolled and rounded masses of them; these blocks being more and more decomposed, and less in size, as they are further removed from their source.* M. Benoist has described the metallic deposits of the recently acquired French dominion of Algiers; the principal of which already being worked are of iron and copper, but lead, antimony, and zinc, also occur; the general direction corresponds with that of the Atlas mountains, and is about east and west, &c.

A very valuable contribution to the mining history of these countries, has been published in the second part of the second volume of the Memoirs of the Geological Survey. Mr. Hunt has here brought together many old and interesting notices of the history of the lead mine districts of Cardiganshire, and Mr. Smyth, mining geologist to the geological survey, has given a full and detailed description of the lodes, mode of working, dressing ore, &c., &c. In the same volume are tables of the amount of copper ores for the years 1845-46-47, produced from Cornish mines, with the amount of copper produced, and the value in money—tables of the amount of ores from foreign mines, and from British and Irish mines, sold at Swansea, from the year 1804 to 1847.

An inspection of the portion of those tables relating to Irish mines suggests some curious thoughts. Of the forty sources from which copper has been derived during the period mentioned above (forty-three years), not a single mine has continued to produce during the

* Comptes Rendus, January, 1848 page 138.

entire period—five have sent ore to market for only one year; twenty-four for no more than five years; eight for ten years; while only five have furnished a supply for twenty years or upwards. Similarly with regard to English and Welsh mines, with very few exceptions, excluding of course, Cornwall. From Cornish mines alone, in the year 1847, 155,985 tons of ore were produced, amounting in money value to £889,927; while *from all other sources,* including 35,700 tons from foreign mines, there were only 50,819 tons of ore sold at Swansea.

We cannot think that this uncertainty in the produce of Irish mines is due *altogether* to an absence of the ore, although frequently it has been so; we *know* it is not due to a want of skill, or technical education, in the working agents in general; but we believe it arises in many cases from ignorance of the true sources of success in mining operation, on the part of *the individuals or companies who undertake these speculations.* There have been also legal impediments now partly removed, and which exerted a seriously injurious effect on such undertakings.

In the same volume, for the first time, and with considerable difficulty, has been given a return of the lead ore raised, and lead smelted in the British Isles for 1845-46, and '47, compiled, as are also the tables of copper, by Mr. R. Hunt, keeper of Mining Records.

The application of geology to agriculture has also attracted considerable attention during the past year. The discovery of the value of some deposits of phosphate of lime, in the cretaceous series, has led to the careful statement by geologists of the position and extent of such deposits, and the probable amount derivable from them, both in this country and in England. M. Durocher has entertained the question of the relation existing between the mineral nature of the soil and its vegetable productions,* with special reference to Brittany. The rocks of that district, without any regard to the age of the geological formations, may be divided into five distinct groups—1st, granites and granitoid schists—2nd, clay slates and greywackes—3rd, quartzose grits and slates—4th, tertiary beds, argillo-gravelly and flinty—5th, calcareous. On the other hand, considered merely agriculturally, there are three great divisions: 1st, tillage

* Comptes Rendus, 13th November, 1848, page 506.

and pasture lands; 2nd, forests; 3rd, heaths and wastes. M. Durocher points out how in Brittany and adjoining districts, the forests are almost exclusively confined to two kinds of formations, the tertiary argillaceo-flinty beds, and still more the quartzite and quartzose schists. These last rocks, although not covering any great extent, contain more of the forests than all the other rocks taken together. The author divides the peninsula of Brittany into four distinct zones; the littoral, on the north and south, chiefly on granite and crystalloid schists; the central, of clayey schists and greywacke, with some tertiary deposits; and the intermediate zones of quartzose rocks, mixed with schists and some granite masses. The coasts are more fertile and more inhabited; next to them the central zone, where pasture lands abound, and which produce most butter: then the intermediate zone in which the forests occur. The prevalence of wood and heath, on the tertiary beds, is stated to be due to the constancy of their clayey character; the kinds of tillage also, and the species of wild plants vary with the formation, the principal variation being due to the clayey or sandy nature of the soil, the presence or absence of calcareous matter, (whether artificially introduced, or naturally present,) and the vicinity of the sea. On the schistose and tertiary deposits of a clayey nature, most of the pasturage, and beautiful grass lands occur; but they are less profitable for the feeding of horned cattle, than the pasturages which are on the argillo-calcareous beds, where the forage grows rapidly.

Buck-wheat (sarrasin) is invariably cultivated on granitic siliceous and argillaceous soils: much less so, and wheat is produced with profit, where they can assist the soil by calcareous additions, lime, marl, or shelly sand, as along the coast, or in the immedite vicinity of calcareous beds; while the culture of sarrasin entirely disappears in Normandy where the secondary limestone occurs; the whole culture is there different—the oak and chesnut give place to the elm. The elm, the maple, and the walnut love the calcareous soils—the oak, the chesnut, the beech, and aspen, love the siliceous and argillo-siliceous. The author points out many other peculiarities, and states, that as far as his observation goes, there is a greater number of characteristic plants on the oolitic and tertiary limestone districts, than on the palæozoic limestone, the latter being less friable. The influence of the presence of lime on the abundance of terrestrial and fresh-water shells, and crustacea, is also pointed out, as being most marked.

In connexion with this subject, I may briefly allude to a communication by myself, during the past year, to this Society, in which I traced on the map of the County of Wicklow, the extent of area covered by the great drift deposits; the variation in their mineral character, from gravels to stiff tenacious clays, and the very important influence which their presence or absence exerted on the productiveness of the land. So long since as the year 1844, in a paper which I laid before you, "On some of the more recent deposits in Ireland," and an abstract of which is published in your Journal, speaking of these deposits, I used the following words:—"And here I would remark, that the richness and fertility of this magnificent amphitheatre," (that including the Dargle, Enniskerry, Kilruddery, &c.) "so contrary to what might naturally be expected from soils derived from an eminently siliceous district, are almost entirely due to the presence of this thick covering of calcareous clays and gravel." And, again, speaking of the districts further south, of Wicklow Head, it was stated, that these same clays and gravels "exercise such a powerful influence on the agricultural produce of the soil, that the outline of these deposits forms a tolerably accurate index to the value of the land." Their importance in affecting the productiveness of the district in other ways, was also pointed out.* That this view was correct, the more detailed examination of the same district in connexion with the Geological Survey, has fully borne out; and on transferring to an index map of the county, the townland boundaries, and obtaining from the General Valuation, conducted under Mr. Griffith, the average money-value per acre for each townland; and representing these money-values by any conventional colours, similar to maps recently exhibited by Sir Robert Kane, to the Royal Irish Acadamy, the interesting and somewhat curious result has come out, that occasionally for miles together, the line, which, on the map representing differences of money-value by colours, corresponds to the line of division of the colours, is identical with the line which, on our geological map, represents the boundary of these drift deposits; the colour indicating the higher money value being *invariably* that which occurs on the portion covered by the drift. Now, although we believe that any conclusions as to the *distribution of soils* of varied money-value, derived from an examin-

* Journal Geol. Soc. Dublin, Vol. III. page 65, &c.

ation of such townland valuations, must be almost useless, excepting *in the broadest and most general way*, owing to the exceedingly artificial and varied nature of these townland divisions; still even an approximate result of this kind offers a strong confirmation of the views I so long ago announced, of the important influence which the geological structure of this district exercises on its agriculture; and a strong confirmation also of the great value of having such a general valuation as that conducted for Ireland, intrusted to the able superintendence of one as intimately acquainted with the geology of the country as Mr. Griffith is. I may also allude to the circumstance that now, for the first time, the extent of these deposits has been shown on our geological maps.

M. Boubeè also has laid before the Geological Society of France a report on a small farm, in which he traces very clearly the immediate and evident connexion which exists between the geological structure and the fertility of the soils. He shows, that on this farm, there are three very distinct kinds of soil. 1st, argillaceo-sandy and ferruginous, (most unproductive)—2nd, clayey, (less sterile)—3rd, argillaceo-calcareous, (fertile.) He points out the cause of the several characters, how completely it depends on the general proportions of the ingredients in the soil, and how *(cœteris paribus,)* this also produces the physical difference as to wetness, tenacity, coldness, &c.; and tracing the geological structure of the country, he shows the immediate cause of these varieties, and points out the economical means of improving them. M. Boubeè very justly expresses his perfect conviction, that the principles of agricultural geology will one day become the true basis of the increased fertility of the land; and that as, without the knowledge of the principles of geology, the pursuit of mines frequently becomes ruinous, so without this knowledge the pursuit of agriculture must equally remain incomplete, and comparatively unproductive.

I am inclined to attach considerable importance to such communications as those to which I have referred, because I believe them to be instances of progress made in the proper direction, and calculated to elucidate the true grounds or rules on which any attempt to benefit the progress of agriculture in a country should be made, so far as *the public* are concerned. To arrive at a knowledge of, or to indicate the actual money value of, the soils of a district, appears to be utterly futile, as this depends on so many changing circumstances,

such as position, increased or diminished facilities of communication, demand for certain kinds of produce, mode of cultivation, &c., so that what might be a fair estimate of the money value of any given soil, derived from an examination of that soil, during any given year or time, might be a perfectly fallacious estimate for any other year or period; but the intrinsic value, as it has been called, or as, at the valuable suggestion of my friend, Professor Handcock, I would call it, the *natural powers* of a soil, these may be, with comparative facility, ascertained, and these ought to be, and must be, the true groundwork on which to base any efforts at improvement. The consideration of these natural powers of the soil enters also as a most essential and necessary element, in all questions as to size of agricultural holdings, relative advantages of various modes of cultivation, or different means of improvement; and in fact into all the questions now exciting interest, as bearing on agricultural improvement. Now, I think, we have clearly seen, even from the limited cases brought before us, during the past year, that these, viz—*the natural powers of any soil—depend essentially on the source from which that soil has been derived; and therefore, on the geological structure of the district;* and as a necessary consequence, that however this latter may have been overlooked, or totally neglected in the discussion of such questions as I have alluded to, such omission is fatal to the proper or complete solution of the question. And further, we may remark, that vast and immediate as has been the benefit conferred on agriculture by chemistry, still the materials on which the chemist operates—the rocks and soils of our country—are essentially geological, and the results carefully ascertained in one instance, can only be safely or readily applied to any other, by a knowledge of the character of these materials, and of the source from which they have been derived. It was from a consideration of this kind, that the system in operation for the collection of soils and subsoils, through the districts under examination by the officers of the Geological Survey in Ireland, was devised by Sir Henry De La Beche, and myself, and is now carried on under my direction; the sanction of the Chief Commissioner of her Majesty's Woods, &c., having been obtained for the necessary expenditure. These soils, &c. are finally handed over to Sir Robert Kane, and I am confident that the results of his careful analyses will prove valuable.

Another direction in which some additions to our knowledge of the

useful applications of geology has been made, has been in the careful examination of the waters derived from known geological sources, and then tracing the effect of the matter held in solution in such cases. Of this, the most prominent instance, during the past year, has been the detailed analyses of the several waters used in those districts where Goitre prevails, by Mr. Grange.* These waters were derived from the talcose, anthracitic, and cretaceous rocks of the valley of Isere. They were all procured on the same day in July, so that the results might be fairly compared. The geological formations of the district are well known, presenting considerable mineralogical and chemical differences, and the mountains are sufficiently high to allow of the examination of waters, taken at different elevations, from the level of perpetual snow, to a few hundred feet above the level of the sea. We shall not enter into any detail, but simply state the results, which were these: that the quantity of dissolved salts increases from the summit of the mountain towards the plain; that, in the talcose and anthracitic formations, the sulphates of soda, lime, magnesia, and potass, diminish relatively to the total quantity of dissolved salts; that in the anthracitic formations, the sulphates of soda, lime and magnesia, are in greater absolute quantities than in the talcose formations, forming from eighteen to thirty-seven per cent.—these formations being rich in pyrites, gypsum, and dolomites; and that in the cretaceous formations, carbonate of lime and magnesia increase considerably. The author details the differences, and points out the importance of such enquiries; and observing in all the waters used in the villages, where cretinism is endemic, a proportion of magnesia, varying from ten to fifteen per cent., he was led to attribute to this salt, the prevalence of this terrible endemic. This view is confirmed by the presence of magnesiferous rocks in all other places where goitre prevails in Europe, and in the Andes also, where the same disease occurs. The author then points out the simple remedy which might be used to counteract this evil, by separating the magnesia, &c.

M. Deville has also given the results of several analyses of drinkable waters, procured from rivers, springs, and wells. The remarkable point of his results is, that he has established the presence of a

* Annales de Chimie. December, 1848, page 364. Comptes Rendus, October, 1848, page 358. Edin. Phil. Jour. January, 1849, page 181.

small amount of silica in all these waters, which had previously been overlooked; from an analysis of six specimens of river waters from different sources, he finds it forms nearly one-seventh of the matter in solution—a somewhat less proportion in spring and well waters; and he considers that this small dose of silica is of great importance in all drinkable waters, and together with the azotized matter, plays an important part in fertilizing land, &c.

The importance of such results, although bearing primarily on the districts from which the waters examined were procured, is by no means limited to them, and they show *how desirable would be a careful examination of the source from which the water was to be procured, as well as of the water itself,* before any definite step should be taken for the supply of this, or any other city, with water for the use of the inhabitants.

The intimate connexion which exists between the varying features of any district, and its geological structure, must necessarily strike any observer; and thus the geologist necesssarily becomes, to a certain extent, a physical geographer. The discussion, also, on the grand scale, of the causes which have produced or modified our mountain chains, the form of our continents, the position of our land, and the extent of its encompassing oceans, all have engaged the deep attention of geologists. There has, however, we think, been a growing tendency to such studies, forming a marked feature in the direction which the pursuits of geologists have recently taken; and such must inevitably be the case, in proportion as the intimate and necessary dependence, which exists between the great cosmical forces becomes daily more and more established.

To Mrs. Somerville we are indebted for a brief and clearly expressed compilation of useful facts on physical geography, from which, no doubt, future editions will remove many of the minor errors, almost necessarily incidental to a work compiled by those who have not themselves examined the questions they discuss. The Cosmos of Humboldt has been completed, exhibiting to the end the same eloquent descriptions, the same abundance of facts, and the same widely extended research, which characterized its commencement. And we have also had numerous illustrations of the physical characters of local districts. But on the progress of such enquiries, the Physical Atlas of Mr. Johnston, completed during the past year,

is calculated to exert an influence infinitely greater than all these works together. Founded on the similar work of Berghaus, but almost as superior to it as it was to the total absence of such maps, this great work has been executed with a skill in the execution, with a research in the details, and with an ability in the mode of grouping them, which reflect the highest credit on those who projected as well as those who carried the design into execution. I shall not detain you with even the briefest allusion to the many important facts laid before the student of natural history or of meteorology in these maps; but simply allude to that portion which more especially concerns the geologist. Here he will find grouped together on one map, the many hundred observations which have been found scattered through books, often difficult of access, often unintelligible to the ordinary reader; but which are here graphically laid before his eye, in these beautiful maps of the mountain chains. Another sheet gives him the valuable chart of the geology of the world, compiled by M. Boué, whose acquaintance with the literature of our science is perhaps unrivalled, and corrected by its author up to the most recent date. And not to dwell on any other feature, we have a palæontological map of the British Isles, drawn up by Professor E. Forbes, and accompanied by very full and carefully prepared tables of fossils, with most interesting descriptions of their geological distribution. This map—the first yet published in which the formations of England and Ireland are correctly synchronized—together with its accompanying letter-press, appears to me the most valuable contribution which has been made to the British geological student for many years.

It is difficult for those who have not themselves engaged in such a work, to estimate the amount of patient, careful, and detailed investigation, which such a publication embodies, the many thousands of observations which are there brought together, and exposed to the eye by some little line; and it is therefore difficult fully to appreciate the value of such a work, as a means of conveying facts, or what is of still greater importance, as a means of arriving at a knowledge of the laws which govern them. When we consider that we cannot take one single step in advance, until we have ascertained and reached the line which marks the boundary between the known and the unknown in the domain of science, and that the measure of that advance must be estimated by the position of the point from which we started, the influence of such condensed and digested exhibitions of the *known*, in

encouraging, directing, and influencing the future progress of science, becomes obvious. To this valuable work of Mr. Johnston we look for supplementary additions, as knowledge increases; and should the hopes of Humboldt be realized, and that 1850 should mark the completion of a magnetic map of the world, such an addition would doubtless be at once suggestive of many unthought of points of connexion between physical geography and geology.

There is also another work, which to me appears by far too important in the influence it is calculated to exert on the future progress of natural knowledge in these countries, to be passed over. We have for many years past been indebted to the officers connected with both the military and naval service of this country, for many useful records of facts, and several valuable contributions to science; and more recently, the results springing from the many voyages of discovery, and surveying expeditions, sent out by the British government, have been both varied and important. Still, considering the number of officers engaged on foreign stations, frequently under circumstances extremely favourable for making observations of great importance, the amount of scientific contributions derived from such sources, was certainly not commensurate with the number of persons engaged. It would be idle to enter into the many determining causes of this; but unquestionably one of these, and a principal one, was the non-possession of some manual pointing out to them the points necessary to be noticed, the methods of observations, the bearing of enquiries, one on the other, and the interest attaching to the result. It was therefore with unmixed pleasure, that we have seen the announcement of a "Manual of scientific enquiry," prepared expressly for the use of the navy, under the sanction of the Lords of the Admiralty. I had hoped that the appearance of this volume would have enabled me to enter more fully on its contents; but the fact that it has been intrusted to the general charge of Sir John Herschel, the choice of subjects, and the names of those selected to treat of them, are sufficient guarantee, that the volume will be such as must materially affect the progress of enquiry; and which, although the honour of projecting it be due to the Board of Admiralty, must equally reflect its influence on the military and on the civil service. Such a step forwards, and in the right direction, must inevitably be followed by a steady advance.

The very imperfect sketch I have been able to give you of the

various communications which have promoted the advance of geology, during the past year, prepared, as it has necessarily been, while fully occupied with other matters, will yet, I trust, be sufficient to prove, that we have not at least retrograded; and that steadily and irresistibly the great tidal wave of knowledge has rolled on. The most distant and inhospitable shores have yielded up their contributions; the nearest and most accessible have been more closely searched. New facts have been accumulated, new phenomena observed, new laws ascertained, the action of new forces investigated; the connexion of our pursuits with the other physical sciences more closely pointed out, and the oneness of action of the great cosmical forces, as to time and place, more clearly demonstrated. Our progress has been certain and definite; our still further advance can never be impeded, while we remember the many useful warnings which the history of every science presents, of the danger of attempting the explanation of phenomena by ill-matured hypotheses, instead of removing the difficulty by exact and cautious observation.

If, gentlemen, I shall in anything have contributed to such sound advance, I shall, *so far at least*, have endeavoured to show myself grateful for the high honour you have done me in placing me in this chair.

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March 14th, 1849.—" On the changes of the Earth's figure and climate, resulting from forces acting at its surface;" by HENRY HENNESSY, ESQ.

The author commenced by observing—That in the present state of Geology, no geological theory which professes to explain phenomena of a general character can be admissible, the results of which do not harmonise with the knowledge we possess of the earth's figure. It becomes important, therefore, to examine how far such a harmony of results exists with respect to certain theories which in recent times have received much attention from geologists.

"Two different general hypotheses, connected with different geological theories, have been proposed in order to account for the observed figure of the earth:

"1. That the earth was in a fluid state anterior to its present state.

"2. That it was always chiefly in a solid state, but that the action of superficial causes might tend to give it a spheroidal figure.

"The first hypothesis, combined with known mechanical and physical laws, serves to account for all the observed phenomena of the earth's figure, and of the variation of gravity over its surface. On the second hypothesis, the latter class of phenomena are inexplicable without the use of additional arbitrary assumptions. The chief phenomenon relative to the earth's figure, for which it is proposed to account by the aid of the second hypothesis, cannot be explained unless it be proved that the effects of centrifugal force, in modifying the position of masses at the earth's surface, predominate over all

other modifying actions. If the predominance of centrifugal force in influencing the direction of the transport of matter at the earth's surface be granted, it will follow, in general, that the mean diameter of the earth at the equator must increase, while that at the poles must diminish. If the earth's figure were not originally spheroidal it would thus tend finally to assume such a form. Let it be supposed to have any irregular shape whatever—let a continuous surface be conceived described around the centre of gravity of this irregular body, such that if the mass of the entire were included within it, the phenomena of its rotation would be unchanged. The axis of stable rotation of this mass, must be that of the greatest or least of its moments of inertia; but as the density of the interior of the mass must be supposed to increase towards the centre, the greatest of the moments of inertia cannot differ much in value from the least, for otherwise the assumption would be made of a greater mean equatorial than polar diameter. It follows, therefore, that the effective surface of rotation of the mass must be nearly spherical, or entirely so, as Sir John Herschel has supposed,* and consequently that of any considerable mass of fluid covering it. If now this mass be set in rotation about its axis, the centrifugal force thus produced would tend to give the fluid a spheroidal surface. The fluid would therefore accumulate about the equator, and recede from the poles. If the surface of the solid mass should, from any cause, become spheroidal, or if its mean equatorial radius should become greater than its mean polar radius, the difference between the oblateness of the surface of the solid and that of the fluid masses would decrease, as I have elsewhere proved.† It follows, that if the earth's figure became continually more spheroidal, the waters would tend to accumulate about the polar regions, and to recede from the equatorial regions. The extent of polar dry land would thus tend towards diminution, while that of the equatorial regions would, on the contrary, tend towards increase.

This conclusion is further confirmed by the following considerations: From what is known respecting the volume of the waters at present covering our planet, it is certain, that if the earth were originally a sphere rotating on its axis, the fluid would accumulate about the equatorial regions, forming an equatorial ocean, while at each pole a

* Astronomy: Chap. iii. page 120.

† Proceedings of the Royal Irish Academy, Vol. iv. page 337.

great continent would exist, having a considerable mean elevation above the level of the sea.*

If the currents tending to transport matter towards the equator predominated in mechanical effect over those tending to transport matter towards the poles, it would follow, that the area of these continents would be continually lessening, and the entire mass would, at the same time, and from the same causes, have a tendency to assume its present oblate figure. If by the action of any forces, land should exist, even to a small extent, in the equatorial regions, it must necessarily follow, that from the cause above assigned, the ratio of its area to that of the circumpolar land, would continually increase. The rising of the level of the equatorial sea, by the deposition of the transported matter of the circumpolar land, cannot affect the truth of this conclusion, because such a rise in the sea level, would everywhere tend, in almost exactly the same proportion, to lessen the area of the dry land.

It may, therefore, be generally concluded, *that at any epoch of the earth's existence, the ratio of the area of dry land at the equatorial regions, compared to its area at the polar regions, should be greater than at any preceding epoch.*

The theory of the earth's figure just considered does not admit of a former state of fusion of the earth, arising from intense heat, and consequently not of any slow progressive change of climate at its surface, resulting from the refrigeration of its mass. Geological observations, especially those which refer to the former existence of organised beings, prove that such a gradual change of climate has taken place; or that, during the remoter periods of the earth's existence, the mean temperature at its surface was higher than at more recent periods. To account for this change of climate, without appealing to a former state of fusion of the globe, Sir C. Lyell has proposed a theory which has deservedly attracted the attention of all philosophical geologists. If, in accordance with the fundamental assumptions of this theory, it be granted, that changes in the relative areas of the dry land and water in the polar and equatorial regions, were the effective causes of the gradual change of climate at the earth's surface, deduced from geological observations, it must follow, that so far as observations reach, the tendency of the

* Proceedings of the Royal Irish Academy, Vol. iv. page 339.

forces modifying the form of the earth's surface was to increase the mean polar diameter, and to decrease the mean equatorial diameter. The hypothesis of the earth's primitive solidity cannot, therefore, serve simultaneously to account for its present figure and for the gradual change of climate at its surface. The hypothesis of a state of fluidity of the earth anterior to its present state, presents no such inconsistency among its results; and, consequently, we are entitled to reject, in its favour, the hypothesis of the earth's primitive solidity.

April 11th, 1849.—"On some Australian Ores;" by JAMES APJOHN, M.D., Professor of Mineralogy to the University of Dublin, &c. &c.

Dr. Apjohn detailed the results of his examination of some copper ores from South Australia, specimens of which had been presented to the University Museum, by the Rev. Dr. Todd.

"Notice of a new chemical examination of Killinite;" by JOHN WILLIAM MALLET, ESQ.

The substance known to mineralogists under the name of Killinite, was discovered in 1817 by the late Dr. Taylor, who read a paper on the subject before the Royal Irish Academy, on the 23rd June of that year, containing a description of the mineral, with its analysis by Dr. Barker, Professor of Chemistry to the University. It has been since analyzed by Captain Lehunt, and Mr. Blythe, pupils of Dr. Thompson. The results of these three analyses were as follow:—

	Dr. Barker.	Capt. Lehunt.	Mr. Blythe.
Silica, ...	58.49	49.08	47.925
Alumina, ...	24.50	30.60	31.041
Protoxide Iron, ...	2.49	2.27	2.328
Lime, ...	"	.68	.724
Potash, ...	5.00	6.72	6.063
Protoxide Manganese, ...	"	"	1.255
Magnesia with Manganese,		1.08	.459
Magnesia, Lime, and Iron,	.50	"	
Water, ...	5 00	10.00	10.00
	95.98	100.43	99.795

Having in my possession some pure specimens of the mineral, I thought it worth while, during a course of analytical instruction under Dr. Apjohn, to make another examination of the mineral, the account of which is the subject of the present short notice. This mineral derives its name from the first and only locality in which it has been found, namely, Killiney near Dublin, where it exists imbedded in coarse granite, and accompanied by crystals of feldspar, garnets, spodumene, and black tourmalin. The specimen on which the following experiments were made, was found in the cutting recently made by the Wicklow, Wexford, and Waterford Railway Company, on the south eastern side of Killiney Hill.

The physical characters of the mineral, as exemplified in this specimen, are as follow. It occurs in small masses, having a foliated structure, and in irregular crystals. It gives by cleavage a rhombic prism, whose angles are about 135° and 45°, as determined by the common goniometer. The fracture is uneven. The colour varies from a light to a dark olive-green, with a shade of brown.

The crystals are frequently found covered with a brownish-yellow coating of peroxide of iron, probably owing to decomposition of the mineral. The streak is white, with a slight tinge of yellow. The lustre is vitreous, but dull.

The mineral is slightly translucent on the edges, but opaque in mass. It is sectile. Its hardness is nearly, but not quite equal to that of crystallized Fluor Spar.

The specific gravity, as determined by three experiments on different carefully selected specimens, was found to be as follows:—

No. 1, ...	2.6603	
No. 2, ...	2.6526	Mean,...... 2.6561
No. 3, ...	2.6553	

This mineral does not attract the magnetic needle. When rubbed on woollen cloth it becomes positively electric. The intensity of its electricity, however, is low. It does not phosphoresce by the application of either friction or heat. The nitric and muriatic acids act on it but slightly, chiefly extracting the oxide of iron which it contains. Sulphuric acid, however, decomposes it, setting silex free.

Before the blowpipe it presented the following phenomena:—Heated in either an open or closed glass tube, it turns black, and gives off a sublimate of water. Alone on charcoal, or in the platina forceps, it turns white, intumesces, and fuses with some little diffi-

culty into a snow-white porous enamel: with carbonate of soda on charcoal, it easily fuses into a brownish-green semitransparent bead, which, with a larger quantity of soda, becomes opaque. With microcosmic salt on the platina wire, it gives a transparent colourless glass. Added in great excess, it gives in the oxidating flame a glass which is transparent, and of a light yellow colour when hot, but which becomes nearly opaque, and assumes a smoke-grey colour when cold. With borax it behaves in the same manner. On the platina wire, with a mixture of bisulphate of potash and fluor spar, it gives the purplish-red flame characteristic of lithia, slightly but distinctly.

Chemical Analysis.

To obtain information as to the chemical constitution of the mineral, the following analysis was made in the Laboratory of the College of Surgeons, under the superintendance and direction of Dr. Apjohn. The method adopted for the estimation of its earthy constituents was as follows: 28.89 grains of a pure specimen were pulverized and strongly ignited, for the purpose of determining the water. This same portion was then fused with about three times its weight of a mixture of carbonate of soda and potash. The fused mass had a light bluish-green colour and radiated structure, very much resembling some species of Wavellite. It was then dissolved in muriatic acid; the solution evaporated to perfect dryness, water digested on the residue, and the silica filtered out. From the filtered solution the iron and alumina were precipitated by ammonia, and these afterwards separated by caustic potash. Oxalate Ammonia was then added to the remaining solution, which precipitated the lime, thus completing the first part of the analysis, there being no perceptible traces of manganese or magnesia. By these means the following results were obtained:—

	28.89 grs. contain		per cent
Silica, ...	15.28	Silica, ...	52.89
Alumina, ...	9.60	Alumina	33.24
Protoxide Iron,	.95	Protoxide Iron,	3.27
Lime, ...	.42	Lime, ...	1.45
Water, ...	1.06	Water, ...	3.67

For the purpose of determining the alkalies, recourse was had to the decomposing agency of hydro-fluoric acid; the vapour of which was made to act upon fifty grains of the mineral moistened with pure water, in the manner pointed out by Brunner.

By this method it was completely disintegrated, the silex being dissipated in the vaporous state, and the other constituents of the mineral converted into fluorides. Sulphuric acid was then poured on, and the whole evaporated to dryness. Being re-dissolved in water, ammonia and carbonate of ammonia were added to it, which precipitated every thing but the alkalies. The solution was then filtered, evaporated to dryness, and ignited to expel the ammoniacal salts. The alkaline sulphates were weighed, redissolved in water, and converted into chlorides, by the addition of chloride of barium. The solution being again evaporated to dryness, they were weighed as chlorides, which having been dissolved in water, the potash was precipitated by chloride of platinum. The residual solution was then freed from the excess of chloride of platinum, by sal-ammoniac, filtered, evaporated to dryness, and ignited, when it left a small portion of chloride of lithium, which was weighed as such, there being no soda present. By this analysis the alkalies were found to be—

In 50 grs.	Potash,....	2.47	=per cent.	Potash,....	4.94
	Lithia,....	.23		Lithia,....	.46

Hence we find the constituents of the mineral in one hundred grains to be as follow :—

Silica, ...	52.89	1.135
Alumina, ...	33.24	.647
Protoxide Iron, ...	3.27	.91
Lime	1.45	.005
Potash, ...	4.94	.105
Lithia, ...	.46	.030
Water, ...	3.67	.408
	99.92	
Loss	.08	

Dividing each of these numbers in the first column, by the atomic weight of the body whose quantity it represents, we obtain the numbers given in the second column above, showing the equivalent proportion in which those bodies exist in the mineral.

Or throwing the lime, potash, lithia, and protoxide of iron into one, we have—

		Relative Proportions.
Silica, ...	1.135	5
Alumina,.............	.647	3
Protoxides,...........	.231	1
Water, ...	.408	2

Dividing each of these by the lowest number, their relative proportions are very nearly as above, which leads to the formula—

$$M\,O, 2\,Si\,O_3 + 3\,(Al_2\,O_3\,Si\,O_3) + 2\,H\,O$$

representing the protoxides by M O.

This formula differs so materially from that of Spodumene, $\left(2\,(Al_2\,O_3, Si\,O_3) + 2\,Li\,O, Si\,O_3\right)$ which is the only mineral liable to be confounded with Killinite, as, I think, to entitle the latter to be considered as a *distinct* mineral species, most nearly allied, however, to Spodumene, and ranking in a chemical arrangement under the alumino-alkaline silicates. The analysis appeared to be worthy of a brief record, as preceding analyses continued the question in doubt of Killinite being classed in mineralogical treatises as a distinct mineral. It likewise possesses some interest in another point of view, as demonstrating the presence in this mineral of the rare alkali, lithia, which has hitherto been found in but small quantity, and sparingly distributed in nature.

May 9th, 1849.—"On the Geology of the County of Carlow;" by PROFESSOR OLDHAM, President of the Society.

This communication was principally a description of the geological map of the County of Carlow, published by the Geological Survey of Ireland. Granite covers all the eastern portion of the county, forming fully two thirds of its entire area. It is of the same general character mineralogically, as the granite of the great axis of Wicklow, and has exerted a precisely similar reaction on the slates which rest upon it. These latter are well seen, covering a very large portion of the Mount Leinster range, (hitherto unnoticed) forming the top of the hill of Tomduff, and in numerous small and detached patches caught up in the granite, on the mountains of Blackstairs, and in the country about Borris and Graignenamanagh. The slates at Tomduff will afford excellent examples of the changes which have resulted from the action of the granite upon them. They abound in Andalusite, Schorl, Staurotide, &c.

A very small portion of the old red sandstone occurs close to Gore's Bridge, being the last portion of the great extent of this rock which occurs in the adjoining County of Kilkenny.

Resting upon the granite at a very low angle, occurs the carboniferous limestone which forms the valley of the Barrow, and is itself capped by the coal measures of the Queen's County and Kilkenny, and which extend for a short distance into the County of Carlow. The subdivisions of the carboniferous limestone into lower, calp and upper, were pointed out, and the reasons for this classification given. The calp only forms a narrow band, of no great thickness. The period of the granitic eruption is clearly seen to be prior to the deposition of the lowest portions of the carboniferous limestone, which is undisturbed by it, and into which no veins of the granite pass.

Covering a very large area of the county, are thick deposits of limestone, gravel, and clay, which, however, diminish very much towards the south; passing into the County of Wexford by the valley of the Slaney, at Newtownbarry, and into Kilkenny by the valley of the Barrow, at Graiguenamanagh and St. Mullins.

The paper was illustrated by the map, and by sections, on a large scale, of various parts of the district.

"The variation of Gravity at the Earth's Surface, on the hypothesis of its primitive solidity; by HENRY HENNESSY, ESQ.

The use of the pendulum as an instrument of geological investigation is twofold.

1. In determining the general laws of the earth's structure.

2. In finding, from observed local irregularities in its oscillations, the position of masses of matter of abnormal density, compared to the mean density of the earth's crust. The first application is evidently the most important for furnishing the fundamental data of geological theory. Any comprehensive theory of geological phenomena necessarily involves the consideration of the earth's general structure; and consequently, in order to be admissible, its deductions should not be opposed to the indications of all extensive series of pendulum experiments. In this paper I propose to examine how far the theory founded on the hypothesis of the earth's primitive solidity, would serve to account for the results deduced from such experiments.

In order to examine the laws of the variation of gravity at the earth's surface, on the hypothesis of its primitive solidity, some sup-

position should be made relative to its interior constitution. It is not allowable to assume, that the arrangement of the interior strata of the earth was originally such as to cause the variation of gravity at its surface, to be that which would satisfy observation.

This would be equivalent to assuming that the strata of the sphere possessed peculiar spheroidal figures; and it may be fairly asked, why should not these figures require explanation as well as the present figure of the earth's outward stratum? If, as remarked by Mr. Hopkins,* the matter primitively composing the earth were of uniform density under uniform pressure, it would follow that the interior strata would be all concentric and spherical.

In this form, as being the only one really admissible, I have already considered the hypothesis referred to, in my paper on the influence of the earth's figure on the distribution of land and water at its surface.† The analytical expressions obtained in that paper will assist in promoting the object of this.

Adopting the notation of the paper referred to, and remembering that $U_i = 0$, $V_i = 0$, when i is not 2, equation (a) becomes

$$C=\frac{4\pi}{3r}\Big[a^3+a_1^3\,(D_1-1)+a_2^3\,(D-D_1)\Big]+\frac{4\pi a^5}{5r^3}\Big[\alpha Y_2+(\alpha_1 D_1-1)U_2\Big]$$
$$+\tfrac{1}{2}gr^2\sin^2\theta.$$

If G represent the intensity of gravity at any point on the surface, having the latitude $90°-\theta$, the above equation will give, after being differentiated, and then divided by $-dr$,

$$G=\frac{4\pi a^3}{3r^2}\Big[1+\frac{a_1^3}{a^3}(D_1-1)+\frac{a_2^3}{a^3}(D-D_1)\Big]+\frac{12\pi a^5}{5r^4}$$
$$\Big[\alpha Y_2+\alpha_1(D_1-1)U_2\Big]-g\,r\sin^2\theta.$$

$$\text{But } \alpha\,Y_2=-\frac{5qD+6(D_1-1)e_1}{2\,(5D-3)}(\cos^2\theta-\tfrac{1}{3}),$$
$$\alpha_1\,U_2=-e_1(\cos^2\theta-\tfrac{1}{3}),\ r=a\,(1+\alpha\,Y_2),$$

hence, on developing r, and neglecting small quantities of the second order, we shall have

$$G=\frac{4\pi a D}{3}\Big\{Q+\Big[\frac{5\,(4D-3)\,q-6\,(D_1-1)\,e_1}{2\,(5D-3)}\Big]\cos^2\theta\Big\},$$

Q being constant, and nearly equal to unity.

* Report of the British Association for 1847, page 43.

† Proceedings of the Royal Irish Academy, Vol. iv. page 333.

Let G_1 represent gravity at the equator, then

$$G = G_1 \left\{ 1 + \left[\frac{5\,(4\,D - 3)\,q - 6\,(D_1 - 1)\,e_1}{2\,(5D - 3)} \right] \cos^2\theta \right\}$$

Using the values of D and D_1 given in my former paper, the cos efficient of $\cos^2\theta$ becomes $\frac{95\,q - 10.5\,e_1}{49}$ By observation this co-efficient is $\frac{5q}{3} - \acute{e}$; $\acute{e}$ being a fraction obtained by combining the results of pendulum experiments, and being greater than the measured oblateness of the earth. The difference between these coefficients is $\frac{7(13\acute{e} - 3e_1) - 55q}{98}$; and hence, in order that it may disappear we should have $e_1 = \frac{98\,\acute{e} - 55}{21}$. But the greatest value of e is $\frac{5}{7}\,q$, hence it is also the greatest value of $\acute{e}$. The observed value of $\acute{e}$ is $\frac{1}{288}$*; the greatest value which it can have, in accordance with the theory founded on the hypothesis of the earth's primitive solidity is $\frac{1}{404.6}$; consequently that theory must be considered as wholly incapable of explaining the observed variation of gravity at the earth's surface.

Recapitulating the results of this and my former papers, which refer to the theory founded on the hypothesis of the primitive solidity of the earth, it may be concluded, that the hypothesis alluded to, entirely fails in affording explanation of the following phenomena :—

1. The secular refrigeration of the earth's surface.
2. The observed ellipticity of the earth.
3. The variation of gravity at the earth's surface, as determined by pendulum experiments.

It is scarcely necessary to add, that the values of the coefficients of precession and nutation, resulting from the constitution of the earth, which has been considered, would deviate widely from their values as observed. Such a result has been already obtained by the distinguished author of the report referred to.†

All these phenomena are completely explicable on the hypothesis

* Humboldt: Kosmos, Bd. I. S. 174.

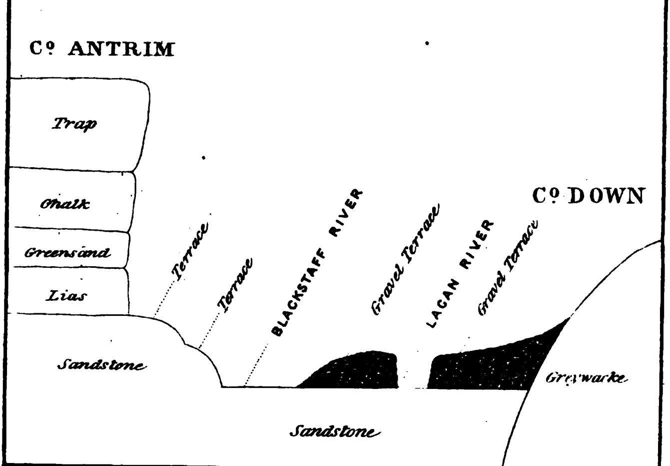
† At page 44 of the Report.

of a fluid state of the whole earth anterior to its present state, and a profound examination of the physical consequences of this last hypothesis, shows that when these consequences are thoroughly considered, seeming discrepancies disappear, and a wonderful harmony is found to exist between theory and observation.

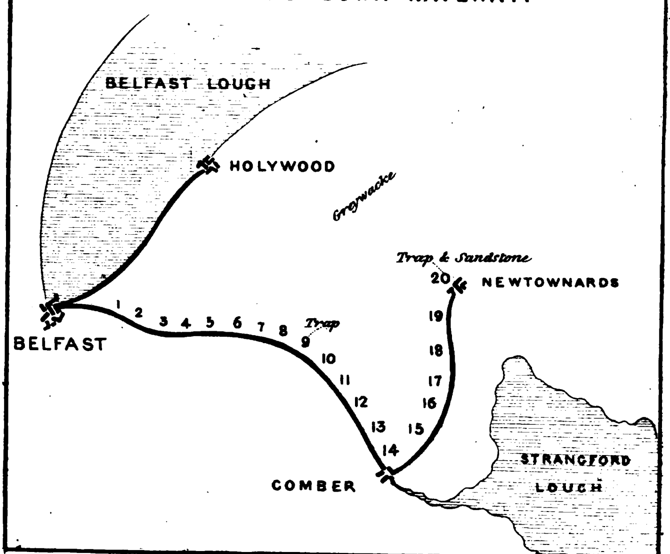
June 13th, 1849.—"On the Geology of the County Kildare;" by PROFESSOR Oldham, President of the Society, Director of the Geological Survey of Ireland.

The author described in detail the geological structure of the County of Kildare, illustrating his remarks by the geological map published by the Geological Survey of Ireland, and by sections. The detail of these investigations will be published in connexion with the Geological Survey.

SECTION ACROSS THE VALLEY OF THE LAGAN OR BELFAST LOUGH.



BELFAST & Cº DOWN RAILWAY.



November 14th, 1849.—"Notice of the former existence of small glaciers in the County of Kerry;" by John Ball, Esq., M.R.I.A., &c.

When visiting the peninsula of Brandon, in Kerry, about three years ago, I was struck with the appearances exhibited at several points on the northern side of the range of mountains which extend from Tralee to Brandon Head, and which appeared to me to be attributable to the operation of extinct glaciers; but owing to circumstances, I was not at that time enabled to examine the phenomena with sufficient care, to justify me in expressing a decided opinion on the subject.

Having subsequently observed in many parts of the Counties of Cork and Kerry, traces of mechanical agency upon the surface of rocks, which evidently were not due to the action of glaciers, but rather to that of floating ice, borne by marine currents against, or along the shores of a glacial sea, I was the more desirous to examine with care those points which had appeared to me to present evidence of the former existence and operation of true glaciers.

During a short visit to Kerry, in October, 1848, I had an opportunity of revisiting a portion of the same district, and of confirming the impression which I had previously received. I proceed briefly to notice some of the facts which seem to me to furnish conclusive evidence of the former existence of glaciers in the south-west of Ireland.

The most accessible, and at the same time the least doubtful site of an extinct glacier which I observed, is traversed by the road which descends from the summit of Connor Hill, towards Tralee Bay. After winding along the face of the steep cliffs of Connor Hill, the road passes at a short distance below a wild rocky hollow in the mountain, which contains a small lake or tarn, called on the ordnance map, Lough Doon. The streamlet which descends from this hollow forms, at a considerable distance below the road, a second small lake, called on the maps, Lough Beirne. A small glacier appears to have filled up the hollow now occupied by Lough Doon, and to have descended nearly to the level of Lough Beirne. The first indication which strikes the observer who ascends from the road to the upper lake, is the regular and uniform manner in which the

rocks at the north-western side of the lake are rounded and smoothed. This appearance is not confined to the flat ledges which lie immediately between the lake and the slope of the mountain, but extends to the steep rocks which form the amphitheatre, reaching to the height of eighty or ninety feet (judging from recollection) above the level of the lake. I observed some traces of furrowings on the surface of these rocks, similar to those which are the common results of the passage of glaciers in the Alps; but as they were not very distinct, and as their origin might possibly be attributed to other causes, I should not have considered the evidence sufficiently conclusive, were it not for the distinct and well characterised moraine, which extends from a little below the upper lake nearly to the level of Lough Beirne. The position of this moraine, which is altogether inexplicable by any hypothesis as to the effects of currents of water, seems to me to leave no room for doubt, to any observer accustomed to the appearance of those bodies. Although its dimensions are masked by the growth of a turf bog upon either side, it forms a distinct and almost continuous ridge, easily traceable by the eye, and which is found on walking along it, to be chiefly composed of large angular blocks, precisely as is seen along the banks of recent glaciers. It is worthy of remark, that this moraine is by no means regularly parallel to the bed of the streamlet, by which the drainage of the upper lake is now conducted.

Although it does not appear necessary to detail the appearances which I observed at other points in the same range, especially as continual stormy weather was very unfavourable to complete or satisfactory examination, I may state that I noticed indications of several other small glaciers, of a similar character to that above described. But the glen which lies immediately beneath the steep northern side of Brandon mountain, and which contains a succession of lakes, the lowest and largest of which is called Lough Cruttia, seems undoubtedly to have been occupied by a glacier of more considerable dimensions. There are, however, some indications which would show that this glacier may have, at different periods, found an exit in different directions; at one time discharging its ice-stream through the gorge below Lough Cruttia, and at others finding an additional vent across the lower part of the ridge, which forms the northern boundary of the lake. Those who may visit the spot in less unfavour-

able weather than I encountered, will be rewarded by a view of some of the wildest and most striking scenery to be found in Britain.

Though but very imperfectly acquainted with the Killarney mountains, I may be allowed to direct attention to the former existence of a small glacier on the north-eastern side of Purple mountain. In ascending from O'Sullivan's road, a little above the woods which clothe the lower slopes of the mountains, the stream is seen to cut through a moraine, which makes a semicircular sweep towards the left, presenting its convex side to the lower part of the mountain. Although the rapid growth of turf bog has completely covered the centre of that side of the mountain, the permeable nature of the moraine has resisted its encroachments, and it offers to the pedestrian the only path wherein his foot does not sink in the spongy masses of *sphagnum*, which so speedily invests every other portion of the surface.

I shall conclude, by suggesting the following inferences from the facts which have fallen within my very limited observation.

1st. Whatever may have been the climatal condition of this country during any previous period, at the time when these small glaciers existed in Kerry, the mean temperature cannot have been excessively low, nor such as would have admitted of any considerable extension of glaciers throughout the adjoining districts. Taking the case which I have described, as a fair example of the other instances of the occurrence of glaciers in the same district, we find that the present height of Lough Doon above the level of the sea is 1117 feet; even admitting that, (as is very probable,) the sea level at the period in question was from 100 to 200 feet higher than at the present time, we still have the fact of the existence of a natural reservoir for snow, at no less than 900 feet above the sea level, surrounded by rocks, which rise above it to the height of more than 900 feet; yet the glacier stream which was fed by the annual overflow of this reservoir, did not—if my observation be correct—descend to a lower bed than that of Lough Beirne, which at the period in question must have been about 500 feet above the sea level. These facts would indicate the existence of a climate but little, if at all, colder than that which now exists in the north-eastern part of Ireland. It is scarcely necessary to observe, that this condition would not have been followed by a colder period, as with the increase of the glaciers,

the moraines must have been carried to a greater distance, and could not have been left suspended on the slope of a mountain, as in the case mentioned on the Purple mountain.

2ndly. The conditions which caused the existence of these small glaciers, must have continued with tolerable uniformity for a considerable time. Although a temperature which must have frequently fluctuated about the freezing point of water, would have caused a far greater amount of disintegration than the very trifling effects now produced on these hard rocks, by the action of the elements; yet considering the very slow rate of annual motion which is attained by small glaciers of slight depth, the moderate extent of rocky surface from which the moraines must have been supplied, and the small proportions which would have been deposited on the lateral moraine, it seems necessary to allow a long period, including several centuries at least, for the continuance of that portion of the glacial epoch, to which the existence of these small glaciers should be referred.

The pressure of other pursuits has made me so ill informed as to the progress of geological investigation in Ireland, that I cannot say how far these trifling observations may have been anticipated by others of a more accurate character. They have been drawn up with a desire rather to direct attention to the subject, than to support any peculiar opinion or theory.

December 12th, 1849.—"On the geology of Howth;" by PROFESSOR OLDHAM, President of the Society.

IN this communication, resulting from the examination of the district by the officers of the Geological Survey, the author detailed the structure and relations of the slaty and sandy beds of which the mass of the hill of Howth is composed, pointing out their extent and mineral character, and the remarkable disturbances and contortion to which they have been subjected. The peculiar arrangement of the so-called quartz-rock was also shown. Numerous dykes and veins of trap rocks penetrate the slates, as near the Baily Light House, the needles, &c., some of them interesting for the extent and distance to which they ramify in the slates. The carboniferous series occurs, resting immediately on these cambrian slates; the lower

beds, seen at Balscaddan Bay, are thin, earthy, and of dark colour, highly fossiliferous. Upon these are seen solid light grey limestones, with the ordinary fossils of the lower limestone of Ireland. These beds are locally very magnesian, of a light dove-brown colour, and full of cavities, which cavities are generally coated with crystals of pearl spar.

Over all, spreads the great deposit of the drift clays, and limestone gravels, occurring in isolated and detached patches along the eastern shore; but forming the surface of all the flatter and less elevated portion of the promontory to the north-west. Some interesting proofs of the amount of degradation which has taken place since the formation of the deposit, are afforded by the occurrence of detached portions of it, forming the summits of what are now islets along the shore, but which must have been, at the period of the deposit of these clays, united with the main land.

January 9th, 1850.—"Analysis of a specimen of mica, from the Co. of Wicklow;" by William K. Sullivan, Esq.

Although there is probably no mineral of which we possess so many excellent analyses as of mica, yet its true constitution is very far from being definitively settled. Recent analyses show, that the substitution of bases may take place to a very great extent; and that its optical and other physical properties are not in such intimate relation with its chemical constitution as was at first supposed: or rather, that our knowledge of that relation is very imperfect. The analysis which I am about to bring under your notice, shows this in a very remarkable manner; and at the same time proves, that even the commonest of Irish minerals affords a wide field for investigation. The specimen examined was obtained by Professor Oldham, during the progress of the Geological Survey of Ireland, and transmitted by him to the Museum of Irish Industry for analysis, under the belief, from the circumstances under which it occurred, that its constitution must be remarkable.

It was devoid of colour, and transparent; but when heated strongly, it became dull, as was also the case when boiled for some time with very strong hydrochloric acid; the edges of the very thin

scales appearing to have been partially decomposed in the latter case. Its specific gravity was not determined. It was biaxial. It was my intention to have made a second analysis, but want of material rendered it impossible to do so; some of the constituents were, however, determined a second time, with the portion employed for the determination of the Fluorine. In 100.000 parts it contained—

			Oxygen.
Silica,	47.411		24.639
Alumina,	36.213	16.951	17.884
Peroxide of Iron,	3.110	0.933	
Protoxide of Manganese,	0.030	0.006	
Lime,	0.014	0.003	
Magnesia,	1.539	0.597	2.188
Potash,	5.510	0.935	
Soda,	2.506	0.647	
Calcium,	0.913		
Fluorine,	0.861		
Water,	2.371		
And traces of Glucina, oxide of Chromium, Boracic and Phosphoric acids.			
	101.008		

The quantity of boracic acid was also determined, and amounted in one case to 0.070; but as yet I do not place much reliance on any of the determinations which I have made of that substance; indeed it is unnecessary for me to mention the great difficulties attending the determination of substances occurring in such exceedingly small quantities, since their determination, when present in large quantities, is still to some extent a desideratum in chemistry. I do not give the determinations of chrome and glucina, for the same reasons; but as I have taken up the subject of the examination of a great number of other interesting specimens of Irish mica, in which these substances occur., I hope to be able to supply this deficiency in a short time.

The mode of analysis did not differ much from that usually pursued, except in the attempt to determine the Fluoric, Boracic and Phosphoric acids. The process followed for this purpose was founded upon the fact noticed by Von Kobell, that carbonate of baryta does not precipitate boracic acid from solutions containing iron; but on the other hand precipitated the entire of the fluoric acid. The mineral was fused with three times its weight of a mixture of carbonate of

potash and soda, the fused mass treated with water, filtered: the solution boiled with a little pure carbonate of ammonia, in order to separate alumina and silica, filtered; chloride of iron added to the solution, then carbonate of baryta, and the whole allowed to digest until the iron was completely separated. The whole of the fluoric acid was then precipitated, as also the phosphoric acid, but not the boracic acid. The solution from which the fluoric acid was separated, was evaporated to dryness, the dry mass treated with sulphuric acid, and then with alcohol, the alcoholic liquor saturated with ammonia evaporated to dryness, ignited and weighed. The iron precipitate was well washed, treated with dilute hydrochloric acid, without heat, and carefully precipitated with perfectly pure caustic ammonia. The precipitate was dried, ignited, and weighed. The weighed mass was then treated with concentrated sulphuric acid in a platinum crucible, covered with a piece of glass, to serve as a test of the hydrofluoric acid, evaporated to dryness, ignited, the ignited mass dissolved in water, to which a little acid was added, the iron carefully precipitated with ammonia, collected on a filter, dried, ignited, and weighed; the difference of weight was calculated as fluorine. The residue of iron was then dissolved in hydrochloric acid, and the first precipitate, (by carbonate of ammonia) of silica, and alumina added to it, the mass evaporated to dryness, heated some degrees above 212°, moistened when cold, with hydrochloric acid, boiled with water, and filtered to separate the silica. The filtered solution was then treated in the manner recommended by Fresenius, for the determination of phosphoric acid.

The oxides of chrome, alumina, and glucina, were separated in the following manner, which is simply an application of the usual methods, employed for the determination of these bodies. The acid solution of the fused mineral, after the separation of silica, was treated with perfectly pure ammonia in excess, the precipitate consisting of the oxides of iron, chromium, and a trace of manganese, alumina, and glucina was collected on a filter, well washed, dried and fused with twice its weight of a mixture of carbonate and nitrate of potash in equal proportions; the fused mass treated with water, which dissolved the chromate of potash, and a small portion of the others, which were precipitated by the addition of a little ammonia. The liquor filtered from the latter precipitate, was evaporated to

dryness, treated with sulphuric acid and alcohol, and then with water, filtered, and the oxide of chromium well washed, ignited, and weighed. The portion left undissolved after the treatment of the fused mass with water, together with the precipitate thrown down from the aqueous solution by ammonia, were then dissolved in hydrochloric acid, precipitated with ammonia, well washed, and digested with caustic potash, filtered; and the iron left undissolved, determined in the usual manner. The solution in potash was neutralized with hydrochloric acid, reprecipitated with carbonate of ammonia, well washed, and a current of sulphurous acid gas passed through it, suspended in water, until the whole was dissolved. The liquid was then boiled for some minutes, until the whole of the alumina was precipitated as sulphite, which was collected on a filter, dried, ignited, and weighed. The glucina was then precipitated with ammonia.

The relation of the oxygen in the bases, with the formula, R O, $R_2\ O_3$ respectively, and in the acid, is very nearly as—

$$1 : 8 : 11$$

which corresponds with the formula $3\ R\ O,\ Si\ O_3 + 8\ R_2\ O_3,\ Si\ O_3$ or in full:—

$$3\left.\begin{matrix} M_n \\ C_a \\ M_g \\ K \\ N_a \end{matrix}\right\} O,\ Si\ O_3 + 8\left.\begin{matrix} Al_2 \\ Fe_2 \\ Cr_2 \end{matrix}\right\} O_3 \left\{\begin{matrix} Si\ O_3 \\ B\ O_3\ ? \end{matrix}\right\}$$

which is exactly the formula for the Fuchsite of Schaffhäutl. In the latter, however, more than three per cent. of the alumina is replaced by oxide of chrome; the mineral is also of a green colour, while the quantity of this ingredient, present in the Irish specimen, is not sufficient to tinge it, and the quantity of peroxide of iron is nearly double that in the Fuchsite. I have, however, since obtained several specimens from other localities, in which the amount is found to vary, between a slight trace, and several per cent, and the depth of colour accordingly, but the analyses of which are not yet completed. The amount of potash substituted by soda and magnesia, is also much greater in the Irish specimen than in the Fuchsite. In the former lime is also present, apparently in greater quantity, than

would be sufficient to neutralize the fluorine, which is not the case with the latter.

It is impossible to say in what condition the fluorine exists in mica, unless we consider that a portion of the oxygen is substituted by it. If, according to this view, we suppose an atom of fluosilicide of calcium to replace an atom of silicate of lime, we would get exactly the same formula as above. If the relation of the oxygen was 1 : 9 : 12, as Rammelsberg remarks, the formula would be much more simple, namely :—

$$R\,O,\ Si\,O_3 + 3\ Al_2\,O_3\ Si\,O_3$$

which would give exactly the general formula of L. Gmelin, if we assumed with him that silicic acid should be $Si\,O_2$ and not $Si\,O_3$, namely :—

$$\left(K\,O,\ 3\ Si\,O_2\right) + 3\left(Al_2\,O_3\ Si\,O_2\right)$$

These considerations lead to the supposition, that this mica, as well as the fuchsite, has undergone very considerable metamorphic action, or that both form an intermediate stage of the transition of slate into true mica.

The presence of soda has been observed in other micas besides the fuchsite; as for instance, in a specimen from Jefferson Co. New York, analysed by Meitzendorff, which contained 0.66, but a trace of lithia was also detected. Not the slightest indication of the presence of the latter could be observed in the Wicklow specimens. The large amount of soda in the latter is easily accounted for by the fact, that nearly all the felspar of the Wicklow granite is albite.

The boracic acid most probably replaces $Si\,O_3$, as I have represented in the formula; but I am utterly at a loss to account for the condition of the phosphoric acid, unless it be merely accidental. I have not attempted to introduce the water into the formula; but this question, as well as many other interesting ones, I hope to be able to treat in a fuller manner, in a more complete examination of the Irish micas, with which I am at present occupied.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 20th, 1850,

THOMAS OLDHAM, ESQ. PRESIDENT, IN THE CHAIR,

The following Report from the Council was read:—

THE Council have to offer to you their report for the past year.

During this period, ten new members were added to the Society, viz.:—A Maguire Giles, Esq.; F. J. Sidney, Esq. L L.D.; Rev. J. Galbraith, F.T.C.D.; Professor Melville, Queen's College, Galway; Thomas Maguire, Esq.; William Dawson, Esq.; Emerson Dawson, Esq.; Rev. A. B. Rowan; Rev. W. A. Willock, F.T.C.D.; and J. G. Medlicott, Esq., an Associate Member.

After due consideration, it was resolved that the under-graduates of the University should be admitted as Associate Members of the Society, on being proposed and seconded in the usual manner as ordinary members, and on payment of the nominal fee of 5s. per annum.

The Council having deemed it expedient that life compositions paid by members should be formed into a reserved fund, £55. stock was purchased, this being the sum paid for life subscriptions since 1845. This stock is invested in the names of Thomas Oldham, Robert Ball, and William Edington, as Trustees for the Society.

A dutiful address was agreed to by the Society, and presented to her gracious Majesty, on her visit to this part of her dominions—an address was also presented to Prince Albert. These addresses were graciously received.

Many members having fallen into arrear, and others having ceased to subscribe, a circular was addressed, acquainting the for-

mer that if their subscriptions were not paid, their names would be removed from the roll of the Society, and offering to restore the latter to the roll, on payment of £1. in lieu of their arrears, and £1. for the current year. This circular brought in a number of arrears, and several old members accepted the conditions, and rejoined the Society, while those from whom it was found impossible to obtain subscriptions have been struck off. The present effective strength of the Society is thirty-three life members, and seventy-seven annual.

Your Council considering that it would promote the objects of the Society, have offered prizes under the following conditions:

"That three prizes be offered by the Society, each of the value of Five Pounds in books, to be awarded for the three most valuable papers in the order of merit, that shall be communicated and read to the Society prior to the 31st of December, 1850, on Theoretical or Descriptive Geology, or the application thereto of any of the kindred sciences.

"Competition to be free to all persons, except to members of the Council of the Society.

"The Society not binding itself to the publication of any papers presented for such competition, nor to award any prize unless papers of adequate merit be presented."

The Treasurer's account exhibits a receipt of £104. 3s. 1d. during the year, out of which, as above stated, £55. has been invested. It will be observed that upwards of £60. has been expended in printing; and it is satisfactory to know that the Journal of the Society is much sought for by kindred institutions.

Abstract of Treasurer's Accounts for the year ending January 1st, 1850.

Dr.	£.	s.	d.
To Balance in favour of Society on last year's Account.	62	8	5½
— Life Subscription,	10	0	0
— Admission Fees,	3	0	0
— Annual Subscriptions,	76	5	0
— Interest on £55., 3¼ per cent. Stock, for half year ending 10th October, 1849,	0	17	11
— Received for articles of Furniture,	0	14	0
— Balance due to Treasurer,	13	6	1½
	£166	11	6

Cr.	£.	s.	d.
By purchase of £55. 3¼ per cent .Stock at £91⅞,	50	13	2
— Gratuity to Servant,	1	10	0
— Printing, Stationery, Books, &c. from *November*, 1848,	69	10	7
— Porter's Wages,	12	0	0
— Assistant Secretary, one year,	20	0	0
— Sundry incidental expenses,	6	8	6
— Collector's Poundage,	6	0	3
	£166	11	6

(Signed)

WM. EDINGTON, Treasurer.

We have examined the above account, and compared vouchers, and find that there is a balance due to the Treasurer of £13. 6s. 1½d.

Dublin, 20th March, 1850.

(Signed)

ROBERT CALDWELL,
R. BALL.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

TO THE LIBRARY.

1849.

May 9.—Rules and List of Members of the Athenæum Club, 1847 presented by the Club.

June 6.—Reports of the proceedings of the Geological and Polytechnic Society of the West-Riding of Yorkshire, 1848, presented by the Society.

June 6.—Quarterly Journal of the Geological Society of London, No. 18, presented by the Society.

June 6.—Geological Map of the County of Carlow, published by the Geological Survey.

July 21.—Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains, decade 1, presented by the Chief Commissioner of Woods and Forests.

July 21.—Sheets 57, 58, and 59 (S. E.) of the Geological Survey of Great Britain, presented by the Chief Commissioner of Woods and Forests.

Aug. 8.—Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains, decade 2, presented by the Chief Commissioner of Woods and Forests.

Sept. 12.—Quarterly Journal of the Geological Society of London, No. 19, presented by the Society.

Oct. 31.—Fauna Antiqua Sivalensis. Nine parts of plates, and one of letter-press, presented by her Majesty's Government, through Sir Henry T. De la Beche, C. B.

Nov. 14.—Meteorologische Beobachtungen Angestellt auf Veranstaltung der naturforschenden Gesellschaft, in Zurich, 1837—1846, presented by the Zurich Society.

Nov. 14.—Meteorologische Beobachtungen angestellt von der naturforschenden Gesellschaft in Zurich Januar bis Dezember 1848, presented by the Zurich Society.

Nov. 14.—Die wichtigsten Momente, aus der Geschichte der Naturforschenden Gesellschaft in Zürich von ihrer Gründung an bis zur. Feier ihres hundertjährigen Jubiläum's, presented by the Zurich Society.

Nov. 14.—Bibliographische Notizen über die Zürcherischen Naturforscher, Geographen, Aerzte und Mathematiker, &c., presented by the Zurich Society.

Nov. 14.—Mittheilungen der Naturforschenden Gesellschaft in Zürich, Heft 1 and 2, presented by the Zurich Society.

Nov. 14.—Proceedings of the Literary and Philosophical Society of Liverpool, during the 37th session, presented by the Society.

Nov. 21.—Quarterly Journal of the Geological Society of London, No. 20, presented by the Society.

Nov. 28.—Report of the British Association for the advancement of Science, for 1848, presented by the Association.

TO THE MUSEUM.

1849.

April 18.—Specimen of Anthracite or Stone Coal from Gwendraeth, Wales, presented by William Edington, Esq.

April 18.—Two specimens of Australian Copper Ore, presented by William Edington, Esq.

April 18.—Specimen of Copper Ore from Cuba, presented by William Edington, Esq.

Resolved.—That the Reports now read be confirmed, and such parts of them, together with the Treasurer's accounts, as the Council may think fit, be printed and circulated among the Members.

A ballot then took place, when the following gentlemen were elected Officers of the Society for the ensuing year :—

President:

LT. COL. PORTLOCK, R.E.

Vice-Presidents:

SIR H. DE LA BECHE, C.B.
JAMES APJOHN, ESQ. M.D.
REV. H. LLOYD, D.D., S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
ROBERT BALL, ESQ., L.L.D.
RICHARD GRIFFITH, ESQ. L.L.D.

Treasurers:

WILLIAM EDINGTON, ESQ.
S. DOWNING, ESQ.

Secretaries:

ROBERT MALLET, ESQ.
PROFESSOR OLDHAM.

Council:

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ. M.D.
THOMAS HUTTON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN,
F. W. BURTON, ESQ.
REV. S. HAUGHTON, F.T.C.D.
PROFESSOR HARVEY,
JOHN KELLY, ESQ.
PROFESSOR HARRISON, M.D.
CHARLES P. CROKER, ESQ. M.D
WILLIAM DAWSON, ESQ .
REV. J. GALBRAITH, F.T.C.D.
F. J. SIDNEY, ESQ. L.L.D.
JOSEPH WELLAND, ESQ.

The President then read the ANNUAL ADDRESS. After the Address had been concluded, the following Resolutions were unanimously passed:—

"That the cordial thanks of the Society be presented to the President, for his exertions in the cause of the Society during the past year, and for the excellent addrsss now read, with a request that he allow it to be printed."

"That the warmest thanks of the Society be presented to the several Officers of the Society, for their zealous attention and endeavours to promote the objects of the Society during the past year.

The Society then adjourned.

ADDRESS.

GENTLEMEN,

At the close of another year we meet once more on the anniversary of the Society, to take a brief retrospect of our progress during the past year, and to strengthen, by mutual intercourse, our hopes and our energies for the coming session.

And seldom has the Society met, when such encouragement was more needed. Our country, still weakened by the misery and suffering consequent on its distress, has been visited, in the all-wise dispensations of Providence, with an alarming scourge. Sudden affliction, and unlooked for suffering, have darkened the gloom of the past year; and we meet this evening thankful, I trust, that we have been saved from the unwonted mortality which hovered around us.

The depression caused by suffering, however, and the anxiety for its relief, are not compatible with that undivided attention which Science claims from her votaries; and while most of us may plead our own losses, or the pre-eminent calls of duty to our fellow-sufferers, as abundant excuse for any apparent neglect of our science which may have occurred, we still must look forward to a more successful future, when greater prosperity around us, may enable many who are now wholly engaged in charitable works, to devote at least a portion of their time to scientific pursuits.

It is, however, no small gratification to be able to state, that your Society has not retrograded during two years of severe trial, in which it has had to contend against the great disadvantages consequent on changes in locality and in other respects, and also against those arising from the general state of the country. Your permanent income has been added to—your numbers have not diminished.

I had last year, Gentlemen, occasion to state briefly, the reasons

why in the few words which it was customary for your President to address to you at your annual meeting, I preferred rather to give a brief outline of what had been done in the principal branches of our study during the past year, including the labours of Foreign as well as British geologists, than simply to review the papers read to the Society itself, with the aim of which, I must suppose you are already acquainted; and I further mentioned the reasons why I thought it convenient to subdivide the subject under three or four distinct heads

I regret much that such a sketch must necessarily be very imperfect. There are not sufficient opportunities here of becoming rapidly acquainted with foreign publications : many works published during, and belonging to a former year, have only reached us during the past twelvemonths, yet cannot, therefore, strictly be included among the labours of the year. And even did those means exist, time has been wanting to me to employ them to advantage. The use of the hammer, to a certain extent unfits the hand for wielding the pen; and constant occupation in the field is not calculated to afford either the opportunity or the desire for much reading. Imperfectly, however, as it must be executed, I shall endeavour to outline a few of the more important papers of the past year.

In doing this, however, I would be understood as anxious simply to lay before you the views of the various authors themselves, in a few cases offering a remark or two on the tendency of, or the objections to, such views. And this, not only because I am inclined to think this the most useful plan to adopt, but also because I am satisfied that the occasion of an address like the present is not one which should be made use of by the President for the advocacy of his own peculiar views on any subject. For this there are manifold other opportunities, which appear to me more appropriate.

Adopting, therefore, in some degree the same classification of subjects, as in the remarks I had the honour of addressing to you last year, we have first to notice briefly such papers on descriptive geology, as have, during the twelvemonths since elapsed, tended to throw additional light on our knowledge of the structure or forms of the earth's surface, of the laws which control its variations, and of the distribution of the many members into which its rocky skeleton may be divided.

Early in the year (19th February, 1849,)* M. Coquand gave a description of the primary and igneous rocks of the *department du Var*, in which he proposes to classify all the varieties which occur there into seven distinct groups, viz.—the granites, serpentines, red quartzose porphyries, melaphyres, (including amygdaloids, spilites, traps,) blue quartziferous porphyries, trachytes, and basalts. The granite is not found to occur in large masses, nor forming an independent group, but chiefly in veins and threads in the gneiss and mica slate, and is subordinate to the crystalline schists. To this rule an exception appears in the plains of Tour; but the porphyritic granite of Roquebrune passes, by insensible gradations, into a gneiss, and even leads to a doubt that gneiss and granite are only different forms of the same rock. The gneiss is much more extensive than the granite; in parts it contains so much graphite, that speculators have been led to suspect a coal deposit, and have even made trials for coal. The gneiss rocks are also frequently amphibolitic and porphyritic, and form a passage between the garnet-bearing quartz and the mica slates. To the gneiss succeed mica slates, containing abundantly staurotide, garnet, tourmaline, rutile, disthene, andalusite, and quartz crystals; and containing also subordinate beds of *siderschist*, a mica slate, in which the mica is replaced by fer-oligiste —a variety now for the first time described in Europe. North-east of Collobrieres it is found in strong beds. There are also seen east of Collobrieres garnets, massive—six, and even sometimes thirty feet thick.

Silky slates, (*les phyllades satineès*) form the outer border of the crystalline schists, and are connected with the mica slates by insensible gradations; but between Collobrieres and Hyeres, the argillaceous slates pass into a dark "*coticulaire*" schist, containing rounded grains of quartz, the presence of which would tend to prove that the crystalline character of the schist is a fact posterior to its deposition.

M. De Beaumont had already observed, and the author confirms the statement, that as regards direction, the beds in the Var belong to two groups; one lying north-east and south-west, the other north and south, corresponding to the two systems of elevation established by De Beaumont, viz.—that of Westmoreland and that of the north

* Bull. Soc. Geol. France, page 289.

of England. The crystalline schists are, *par excellence*, the locality of the quartzose and metalliferous veins.

Of the serpentine there are only three or four masses of any extent. All the serpentine of this district is remarkable, as being entirely free from *diallage*, but is very asbestiferous. It is used for ornamental and other economical purposes. Chromate of iron is found in one or two places, in rognons more or less large. Talc is found interlaced in small threads, like the ores of copper in the serpentine of Tuscany. It is difficult to decide the precise age of this serpentine; but every evidence which there is tends to prove that it is more ancient than the jurassic system, being like the serpentine of the Vosges and of Limousin.

The red quartziferous porphyry forms almost the entire mass of the Esterel, and gives a peculiar physical aspect to it; sharp peaks, and irregular indentations cutting in a hard line against the sky, contrasting strongly with the rounded tops and long slopes around. The valley of Reyrau divides the mass into two parts, or unequal bands. In the constancy of its mineral constituents, this rock forms one of the most marked and best defined terms in the igneous series; and there is as little doubt as to its age, or its relations with the rocks which it traverses or which cover it. The paste is generally a petrosiliceous orthose, of a more or less distinctly red colour, containing numerous simple or hemitrope crystals, of a paler orthose, and also grains of quartz, which in crystalline form approach the dodecahedron. These red porphyries appeared during the period of the *gres-bigarrè*, as is clearly shown by the fact of the lower beds of this group being altered by their contact, while the upper are made up, in a great degree, of the debris of the porphyry itself; and besides, the porphyry has been affected by all the subsequent disturbances of the *gres-bigarrè*.

Under the head of Melaphyres, are included all the varieties of spilites, trap, amygdaloid, wacke, and melaphyres, which may all be taken as one great series, differing in the minerals included; and which might be subdivided into four groups of granular, porphyritic, amygdaloidal, and variolitic melaphyres. Of all these the geological epoch is, according to the author, anterior to, or at least cotemporaneous with, the *gres-bigarrè*. He further thinks, that the successive appearance of dolomitic beds, is in some way connected with the

successive eruption of these melaphyres—not altogether by subsequent alteration, but by the circumstance of the waters at these successive times holding carbonate of magnesia in solution. The melaphyres as a whole, form one geological formation or group, of which the first appearance followed quickly the deposits of the earliest beds of the gres-bigarrè, and which is also connected with the appearance of some metallic veins, and of gypsum and dolomite in Provence and parts of Dauphinè.

The blue quartziferous porphyry, in which the paste is formed of oligoclase, and in part of albite, with dodecahedral crystals of quartz, (which forms one of the essential elements,) the author believes to be the cause of the disturbance of the Esterel.

The trachytic group is very variable in composition; as to age, apparently anterior to the miocene, and posterior to the nummulitic group of the middle of France. The basaltic group is of later date, and produces very marked disturbances and alterations in the rocks adjoining. Of the several facts stated, M. Coquand gives a tabular view, exhibiting the geological period of the production of the several groups of igneous rocks, and the class of veins associated with, and dependent on them.

Large, however, as these masses of igneous rocks are, to get a true notion of their relative importance, we must compare their extent with the area of the seas in which the eruptions occurred; and thus—as the author very justly remarked in reply to objections raised—it would appear that such exhibitions of igneous matter would bear a smaller proportion to the area over which deposits were going on at the time, than the recent cases of the formation of islands in the Mediterranean, would to that sea; and yet no one would expect any appearance of disturbance, other than very local, from such a cause.

M. Daubree has established the very interesting fact, that the granite of the Vosges at Champ du feu, was produced prior to the silurian rocks of that district, in which rolled masses of this granite occur. In those slates fossils are found; while at the other side of the granite mass, slates occur, in which no fossils have hitherto been noticed, which are of a totally different lithological character, and which are traversed in all directions by veins of the granite. There

are thus two distinct systems of slates, intermediate between the deposition of which the granite intrusion took place.*

In two communications† which I myself brought before this Society during the past year, I had occasion to point out the distinct evidence which existed as to the age of the granite rocks of the south-east of Ireland; showing unquestionably that the granite was subsequent to the latest silurian rocks we found in the same district, and long prior to the old red sandstone conglomerates, which in part contained rolled lumps of the granite. If it be sought to ascertain more closely its age, it must be borne in mind, that the only group of the silurian series represented by the rocks in connexion with this granite, is the lowest, or the equivalent of the Llandeilo group; while, at the same time, the occurrence of the rolled masses of granite in the conglomerate of the old red, proves not only the existence of the granite, but further, that it had been long exposed at the surface, and subjected to the action of the degrading and wearing forces, which formed the well rounded lumps we now see imbedded in the sandstones. And in connexion with this I might remark, that in such enquiries regarding the geological epoch at which certain protrusions or intrusions of igneous rocks have occurred, especially of granites, some most important and indeed essential considerations appear to me to be too frequently overlooked The epoch of intrusion is often taken as equally that of protrusion. The time at which the molten matter has been forced into and among the stratified deposits above it, has been confounded with, or even in many cases tacitly assumed to be the same as that at which the same igneous rock has come to the surface, and there become subject to the operation of ordinary mechanical forces. Now, especially in reference to granite, of which we were more immediately speaking, no misconception can possibly be more fruitful of error than this. Independently altogether of the physical impossibility of conceiving a rent in the earth's crust, through which a mass of matter in a state of igneous fusion, extending for some sixty miles in length, and occasionally fifteen to twenty in breadth, (such as that of Wicklow and Wexford) could come to the surface, without—to use the forcible words of

* Comtes Rendus, tom xxix. page 114.

† Jour. Geol. Soc. Dublin: On the Geology of the County Carlow, vol. iv. page 146. On the Geology of the County Kildare, vol. iv. page 150.

Darwin—the very entrails of the earth gushing out, it must be remembered, that nothing is more thoroughly established than this—that the peculiar mineral or lithological character which any of these igneous masses assumes, depends essentially on the peculiar circumstances in which it is placed, or the peculiar conditions to which it is subjected, while cooling. As far as we know, also, certain conditions of pressure and continued high temperature are essential to the production of a granite, which conditions cannot exist at the surface of the earth. Granite, therefore, or in other words, the formation from a molten mass of mineral matter, of that peculiar kind of lithological structure or mineral texture, to which geologists have applied the term granitic, being the result of certain definite conditions, which conditions have not existed at the surface of the earth, the mere occurrence of any mass of granite now appearing at the surface appears to be in itself perfectly conclusive evidence of very considerable changes in that portion of the earth's surface since the formation of the granite; for had the fused or molten mass become subject to the conditions there existing, it would no longer have formed granite, but would have assumed a structure very different indeed from that indicated by this term. The forces which suddenly brought the cooled mass to the surface, may have been of the same kind, or the result of the same general cause; but whatever it were, it must have been exerted subsequently to the consolidation of the mass, under conditions very dissimilar to those which could exist at the surface. While, therefore, the occurrence of granite pebbles in any rock, proves that the granite from which these pebbles have been derived, was exposed at the surface prior to their deposition, their absence, on the contrary, can only be taken to establish the opposite of this, *and even this not conclusively;* but will by no means serve as a proof of the *non-existence* of the granite, or in other words, of the subsequent intrusion of it. We are so very prone to forget the successive and enormous changes through which the surface of our globe has passed, and to reason from tacit assumptions, that the former aspect of that surface has been very similar to its present one, that such a caution appeared desirable. I have felt the necessity of attending to it frequently myself, and I can trace the results of a neglect of such considerations in the statements of others.

Dr. Dale Owen* has published the results of his examination of the northern portion of the United States, up to 49° of north latitude, embracing the Red River, Lake Winnipeg, Rainy Lake, and the northern border of Lake Superior, as well as the St. Pierre River, and its tributaries. Though not entirely completed, he thinks sufficient has been done to prove that there are five or six distinct beds containing trilobites, in the lower group, hitherto supposed to be without any fossils of that kind. These beds are entirely below the lower magnesian limestones of Wisconsin and Iowa, which is the equivalent of the lead-producing limestones of Missouri, and of the calcareous group of New York. Some of the trilobites found are remarkable for their long spiny appendages, occasionally several times as long as the body of the animal.

The devonian rocks described in 1847, as found in the southern portion of the Dubugue district of Iowa, have been proved to extend far up the valley of the river Lower Iowa, and of its tributary, the Red Cedar, and as far as Lime-creek and Shell-creek.

Of each of the subdivisions of the several groups, the author gives a detailed account. Viewed on the large scale, the lower portion appears to be characterized by a series of sandy beds with slaty partings, frequently covered with lingulæ and oboli, and with layers containing abundance of trilobites, at least of individuals; the upper portion is, on the other hand, more calcareous. Working under considerable difficulties, in countries almost inaccessible, much of the journey performed in canoes, carried by the party themselves across the country, frequently without seeing a human being for weeks, Dr. Owen and his party have thus tracked out the great lines of subdivision of the series of rocks which spread over this enormous tract, and have clearly shown, on the great scale, their relation to, and agreement with, similar groups acknowledged by geologists. They have also thrown much light on the economic relations of the district, and have pointed out the occurrence of numerous veins of lead, &c., a portion of which has been already opened, and with profit.

Professor Nicol† has more fully established the silurian age of the slate rocks of the south-east of Scotland, having discovered graptolites in them in several localities. He has found six species, one of

* Bull. Soc. Geol. France, tom vi. page 419.

† Quar. Jour. Geol. Soc. London, 1850, page 65.

which is new (*G. griestonensis*,) and they all tend to show that these slates belong to the lower silurian, and are equivalent of the Llandeilo-flag series. Mr. Nicol points out the close resemblance which these rocks and their contained fossils have to the silurian rocks of the County of Tyrone, described by Portlock. He gives a rude estimate of the thickness of these deposits, derived from calculating an average dip over a known extent of surface; and supposes that they have a thickness of forty thousand feet. Exceeding caution is necessary in admitting the truth, even as a very rude approximation, of such calculations. Indeed, with the older rocks in these countries, there are very few instances in which they are not more apt to lead astray than otherwise, for they proceed on an assumption which everything seems to disprove, namely, the constancy of dip either as to direction or amount. And I feel perfectly satisfied that many, if not most of the estimated thicknesses of the older stratified rocks will be enormously diminished, when the districts in which they occur are more closely examined. A thickness of regularly stratified deposits of *an uniform average character, and regularly superimposed during the period of the existence of the same group of organized creatures*, amounting to nearly eight miles, is to my mind, an impossibility, or nearly so; inasmuch as the production of such a series must involve such continuous changes of level of land and sea, and such continued and immense degradation of previously existing rocks to furnish the materials, as, under the circumstances of the case, appear to me totally inadmissible.

Professor Nicol derives from the structure of the south-east of Scotland, as he has described it, some very forcible objections to M. Elic De Beaumont's theory of the system of elevations, and further points out the interesting connexion of the position of some axes of elevation with remarkable physical peculiarities, particularly the river drainage. He believes that the very irregular boundary line between the old red sandstone and the silurians in the south, as ontrasted with its nearly straight line on the northern margin, is to be accounted for by the circumstance that the old silurian rocks on the north formed a sea coast, where they were exposed to the wasting influence of an open sea, while the southern portion was being cut into valleys by river action. Professor Nicol concludes his paper by descriptions of the graptolites found in these rocks.

M. Tchihatchef* has given a brief sketch of the results of his long-continued researches in Asia Minor, during which he believes he has established the fact of devonian rocks covering a large portion of that country, and that the "gypsum and red sandstone" formation, the age of which was unknown, contains nummulites; and as to the area covered, is the most extensive formation in Asia Minor.

Mr. Hamilton who, in conjunction with Mr. Strickland, had already contributed much to the geology of other portions of Asia Minor, has now published his observations in the more eastern parts of the country. The extent and variety of the igneous rocks which have pierced and disturbed the area is very remarkable, while the stratified rocks, being for the most part deficient in fossils, it is difficult to give any definite classification of them. He has subdivided them, therefore, into two great groups of secondary and tertiary; the former being of two ages, one the lower secondary, probably representing the jurassic or oolitic system; the other, the upper secondary, probably corresponding to the cretaceous system. Upon them rest the nummulitic group, basins of rock salt, marl and gypsum, and other rocks. The mineral character and arrangement, as far as it could be ascertained, of these several groups of deposits, is described.†

The geology of the several countries visited by the American exploring expedition has been published—a large volume full of details, and illustrated by a volume of plates of fossils. Among other notices, we have from M. Dana an account of the geology of Upper California, which has excited so much of public attention from the abundance of gold found there, and some valuable information on the same district has been also contributed by the Rev. C. S. Lynam.‡

Mr. Dawson has described in considerable detail, the appearance presented by the curious masses of gypsum and associated marls which occur at Plaistercove, in the Strait of Canseau, near Cape Breton, and endeavoured to point out the successive steps in its formation §

Professor Göppert, whose contributions to Fossil Botany are well

* Quar. Jour. Geol. Soc. London, 1849, page 360.

† Quar. Jour. Geol. Soc. London, 1849, page 362.

‡ Sillimans' Journal, 1849, page 290 and 305.

§ Quar. Jour. Geol. Soc. London, 1849, page 335.

known, has published the essay on the coal formation of Silesia, to which the Haarlem Scientific Society awarded its prize. In this valuable work, illustrated with numerous plates of the fossil plants found in the coal measures of that country, the question of the origin of the coal, whether from drifted vegetable matter, or from the decay and subsequent mineralization of plants growing on the spot, is fully discussed; and with more especial reference to Silesia, the distinctive peculiarities of the coal beds in upper and lower Silesia are ably pointed out.

M. Saemaan has given* a general sketch of the relation of the chalk group of the north west of Germany, and of the same formation in France. He considers the *unterer-kreide-mergel* of M. Roemer, to be the true representative of the white chalk, containing *Ananchytes ovata, Terebratula defrancii, carnea, Ostrea vesicularis, Plagiostoma spinosum, belemnitella mucronata,* and a tooth of *mosasaurus.* In opposition to this opinion, was the idea that cephalopods with ornamented septa (*a cloisons decoupèes*) ceased in the upper chalk, while in reality they attain a great size in it. The *ammonites peramplus,* usually quoted to prove the age of this deposit, is not, according to M. Sæmaan, the species known under that name in Touraine, being more nearly related to A. *lewesiensis.* The bed below this in the upper part is full of green grains, of a very marked colour, which gradually decreases in the lower parts. It is very poor in fossils, but contains *ammonites varians,* fortunately characteristic, and which proves it to be the equivalent of the upper chloritic chalk. Next below, we have a compact limestone, grey and marly, much like some of the varieties of the planerkalk of Saxony, and containing many *inoceramus mytiloides.* The lower bed is a grey-brown friable argillaceous sandy bed, not calcareous, containing much pisolitic iron. The lower portion has no grains of quartz, the iron alone forming the base, and it rests directly on the coal measures. This is the *hils conglomerat* of M. Roemer, considered for a long time to be the equivalent of the Neocomian. The fossils from it, however, all tend to show that it is the representation of the *upper* green sand, such as ostrea carinata, exogyra haliotidea, discoidea subuculus; and there is not a single neocomian fossil (*exogyra sinuata,* quoted by Rœmer,

* Bull. Soc. Geol. France, tom. vi., page 446.

being probably a mistake.) The *hils conglomerat* agrees most remarkably with the *tourtia* described by D'Archiac, and to which we referred last year. There are the same terebratulæ; as *T. biplicata, latissima, paucicosta, canaliculata, nuciformis, nerviensis* (longirostris of Rœmer,) *tornacensis, subundata* (Roemer.)

The lower portion of the same group—the *hilsthon* of Rœmer, equally contains no neocomian fossils, according to Sæmaan, nor has he found any trace of the gault in Germany.

Among the most important communications which I noticed last year, it will be recollected was Sir Roderick Murchison's determination of the age of the great and widely extended group of rocks containing nummulites. At that time, this valuable paper had not been published at full, and I was obliged to rest satisfied with brief abstracts. Since then, however, it has appeared, and it is certainly one of the most important contributions to geological knowledge which recent years have afforded, whether we consider the amount of observations grouped, or the importance of the classification now introduced.

For the details of Sir R. Murchison's labour, and the numerous and satisfactory proofs on which he bases his conclusions, I must, however, refer to the paper itself, which will be read with pleasure by every geologist.

Bearing on the same subject, M. Victor Raulin has added to his former communications some additional notes on the nummulitic rocks of the Pyreneés, and has shown that what he had before established for the western portion is equally true for all, viz.—that the cretaceous group is there as perfect in its upper portion, as in the basin at Paris, or at Maestricht; and he thinks there are not even plausible reasons for supposing the *terrain a nummulites* to be any part of it.* M. De Verneuil† has established the range of the nummulitic group in the Asturias, and has there entirely confirmed the views of Sir Roderick Murchison. M. De Zigno, also, in a general sketch of the geology of the Venetian Alps, (in which‡ he

* Bull. Soc. Geol. France, tom. vi. page 531.

† Phil. Magazine, July 1849, page 34. He has also pointed out some peculiarities in the carboniferous group of that country, and states that the coal there is subordinate to the mountain limestone, as in Northumberland and Scotland.

‡ Comtes Rendus, tom xxix. page 15.

states, that by the guidance of fossils alone, he has been able to identify the triassic, lower and middle oolitic groups, and traces of the upper, and to point out the several divisions of the cretaceous group,) has subdivided the tertiaries of that district, which had hitherto been all grouped together, and considered miocene, into eocene, miocene and pliocene; and has satisfied himself that the nummulites are altogether eocene. He corrects an error, into which he had formerly been led by imperfect specimens, supposing that he had found nummulites in the scaglia, and he now thinks that the nummulite is the most characteristic fossil of the eocene group.

The eocene rocks of America have been illustrated by the memoirs of Mr. C. S. Hale, on the geology of south Alabama,* the surface of almost the entire state being composed of rocks referable to that geological epoch; and of Mr. Holmes, who has described the formation on which Charleston, South Carolina, stands. This author also gives a list of one hundred and forty-seven species of post-pliocene fossils from the beds there; detailing at the same time the section of the eocene beds, including the remarkable one in which the *zeuglodon* has been found, and entering into detailed particulars as to the structure and arrangement of the series.

M. Hebert has very carefully examined the fossils derived from the tertiary argillo-sandy beds of Limbourg in Belgium, and thinks that M. Nyst has been in error in referring them to the parallel of the *calcaire grossier,* to which they have but slight analogy, and according to M. Hebert not a single identical fossil. He points out for each species the differences between those assigned by M. Nyst to the Paris Basin, and to the beds of Limbourg. He thinks these beds are really the equivalent of the *ostrea cyathula* beds of the Paris basin, which occur at the base of the fifth group of Brongniart and Cuvier, or the second marine group. This communication, if M. Hebert's results be substantiated by further enquiry, will effect a great change in the classification of the tertiaries of Belgium.‡

M. Prestwich has established the existence of some fossiliferous beds, overlying the red crag at several points in Suffolk, and remarkably contrasting with it by the perfect evidence they afford

* Sillimans' Journal, November, 1848, page 154.
† Do. Do. March, 1849, page 187.
‡ Bull. Soc. Geol. France, tom vi. page

of the quiet and tranquil deposition from which they resulted. The organic remains also, instead of occurring heaped together in confusion, and often fragmentary, as is generally the case in the crag, are regularly perfect, and lie in the position in which the animal lived: the bivalves have constantly both valves together. These sands and clays, from ten to twenty feet thick, are immediately overlaid by the coarse clay-drift. Out of twenty-three species of shells, only one, or possibly two, do not occur recent; all, or nearly all, occur in beds of the age of the Clyde pleistocene beds, and the whole character of the fauna is arctic. The paper is distinguished by that conscientious and accurate attention to detail, and that simple and effective statement of facts, which have characterized all M. Prestwich's communications.

Mr Ringler Thomson* has been led, by the unvarying position in which the bivalve and univalve shells are found in the crag of Suffolk and Essex, to speculate on the cause of this fact. He observes that the countless number of pectunculi and other shells are deposited in layers of various thickness from six inches to as many feet, "each shell having its inside concavity downwards, and the umbones of the shells having in general an easterly direction." He found by repeated experiments, that in waters, whether at rest or in motion, the shells were invariably deposited with their concavity or inside upwards, and univalves with their mouths upwards; and from this not being the case in the crag, inferred that although water may have transported them to their present localities, it could not have been the cause of their actual position. And suspecting the wind might be so, numerous experiments were made, and it was observed, that in all cases the shells, however originally placed, were turned over or came to rest with their concavity downwards, and with their umbones turned towards the point from which the wind blew. If these experiments be considered conclusive, the shells in the crag, which present this remarkable arrangement, must have been left dry, and subjected to the force of a long continued east wind, probably of considerable force. These speculations of Mr. Ringler Thomson. appear to me very interesting and curious, as opening up a class of observations which may, by judicious extension, be fruitful of important deductions regarding the forces which have tended to modify

* Quar Jour. Geol. Soc. London, 1849, page 354.

the disposition of materials on the earth's surface at early as well as at recent geological epochs. On more occasions than one in this Society, and even so recently as in December last, I have had occasion to notice the peculiar character and disposition of some of the sandy masses in the older slates, and to point out how perfectly analogous they were in their arrangement and materials, to many of the sand dunes of the present day, (excepting, of course, their subsequent induration.) And I feel satisfied that many more instances could be adduced, in which the wind, as well as waves, could be shown to have been a very effective agent in producing or modifying geological results. And if in such enquiries, we can derive additional evidence from the position of the fossils imbedded, we most gladly accept the slightest glimmer of additional light, which such observations are calculated to throw on the origin and mode of formation of the masses.

In a brief notice of the tertiary, and some recent deposits in the Island of Nantucket, by Messrs. Desor and Cabot, the authors describe the varying mineral character and position of the beds of sand, gravel, and clay, which rest upon the tertiary clay of that district, and which are considered as forming part of the "drift." And from the similarity of the fossils found in these beds at Nantucket, to those of the newer pliocene of the southern States, the authors conclude that they form a link between the northern and southern deposits; and that, instead of considering them as so many distinct formations, we must henceforth view them simply as modifications of the same great deposit, the result of the same agencies; these being oceanic tide-currents along the whole coast of the United States—local variations being fully accounted for by local changes in the strength or direction of these currents.*

M. Collomb has endeavoured to bring into a chronological arrangement, the quaternary deposits of the valley of the Rhine, more especially with a view to establishing the connexion between those in the plains and those in the mountains.†

In the plains, these deposits consist of two distinct groups—

1st lower, of sand and pebbles.
2nd upper, of sand, clay, and marl, or *lehm*.

* Quar. Jour. Geol. Soc. London, 1849, page 340.
† Bull. Soc. Geol. France, tom. vi. 479.

The lower part is called by M. D. Archiac, the *formation erratique*. The upper has many names, *lehm*, *loess*, diluvium, ancient alluvion, &c., but all authors agree in distinguishing these two groups. In the upper group or *lehm*, ninety-six species of shells have been found by Messrs Braun and Walchner; of these fifty-six are terrestrial, and forty fluviatile; seven belong to living species, and nine others are probably only varieties of living species. Those forms, however which are most common now, are the rarest in the *lehm*, and *vice versa*. The very common recent species, which love warm and dry exposures, never occur in the lehm, while the perfect preservation of the shells proves that they lived where their remains are now found. Besides these, we have remains of *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus caballus fossilis*, *Bos priscus*, *Cervus euryceros*, and other extinct quadrupeds, the remains of which are very little rounded or altered; and it is not uncommon to find a large portion of the bones of the same animal still united.

In a similar manner the formation in the mountains is composed of two distinct groups, which have a chronological relation with those of the plains, but differ essentially in their composition, their external aspect, and the arrangement of their materials. One of these has been called *terrain erratique;* but to avoid all confusion arising from this name, the author purposes to call it, including the moraines, erratic blocks, and all debris of every kind transported by ancient glaciers, the *terrain glaciaire*. This distinction is especially necessary, as the "terrain glaciaire," and the "terrain erratique" are not cotemporaneous. There is no question that among the mountains, these deposits have had a glacial origin; but the ancient glaciers which formed them have never extended into the plains of the Rhine nor of the Moselle. Besides this glacial formation, there is in all the valleys of the Vosges mountains, another which the author provisionally calls, *formation inferieure*. It fills the lower parts of the valleys—is composed of the same elements as the glacial deposits, but differs essentially from them in the degree of wear of the materials, and in the place which it occupies, being constantly below the other. It is besides always stratified—large blocks are rare, sand and gravel prevail. On this formation, wherever the rock *in situ* is not exposed, rest the moraines.

Above both, there are sometimes turf-bogs, frequently caused by

the glacial moraines having dammed back the water, and caused marshy ground, on which peat grew, and these seem to indicate the termination of the glacial period, and the commencement of the existing order of things. This passage he believes to have been very gradual, but marked by a greater force of watery currents, &c. than at present; this additional force arising, not from the melting of the glaciers—which before this had retired to the limits they occupy at present—but to the naked and unclothed surface of the ground, arising from the action of these glaciers, and before there had been time for it to become clothed again. This state of things has given rise to old torrent beds, in some of which torrents still flow, but in many not.

Such being the deposits in the valleys of the Vosges, what is the chronological connexion between these and those found in the plains? Now the lower deposit of the plains is perfectly continuous with the lower deposits of the hills; it does not differ in the nature of its materials, but only in the mode of their aggregation, being horizontal and continuous in the plains, but in terraces in the hill-valleys. These are therefore identical. The *lehm*, on the other hand, is not so easily traced; it does not spread into the mountain valleys at all, but is constantly separated from the moraines there, by a band of pebbly sand. In fact, the author supposes this *lehm* to be nothing but the mud of glaciers, not deposited or left by the glacier itself, but derived from the glacier, and deposited by water, rivers, &c. in the plains.

Thus we have, as the three necessary results of the existence of these glaciers, the striæ and polishing of the rocks, and the moraines in the mountain valleys, and thirdly, the mud, in what is now called the *lehm*. All the shells found in the latter indicate a period of cold.

M. Collomb therefore concludes, that the two quaternary deposits of the basin of the Rhine, viz.—the lower, or erratic, of M. D'Archiac, and the upper, or *lehm*, in the plains, correspond chronologically with the lower, and with the upper, or glacial, of the mountains—the striæ, moraines, and the *lehm* being the results of one and the same cause, and not separated chronologically.

In connexion with these deposits, M. Scipio Gras has arrived at the following conclusion with regard to the Alps:—

1st. The vegetation which clothed the Alps at the close of the

tertiary epoch, and of which the existence is proved by the various deposits of lignite, as well as various remains of ruminantia and pachydermata, had completely disappeared at the period of the transport of erratic blocks.

2nd. This vegetable denudation confirms the hypothesis of an extraordinary extension of glaciers, covering the Alps, at the epoch of the erratic phenomena.

3rd. Afterwards, by the return of a milder temperature, this covering of snow and ice was removed, and their flanks, then entirely naked, were exposed for a long period to the powerful action of atmospheric causes. It was at this time that most of the deep ravines and funnel-shaped cavities were formed, and the materials produced deposits posterior to the erratic blocks, but still anterior to historic time.

4th. After a considerable time vegetation spread again over the the Alps, and

5th. Finally, Man commenced to inhabit the district.

M. Studer has studied the quaternary deposits of the Tyrol,* where he finds an enormous development of the "erratic block" group composed of gravel and sand. This appears to have filled, before the existent epoch, a large portion of the valleys. There is an immense development of it near Insbruck. M. Studer thinks it evident that these deposits belong to a state of things during which the inclination of the river courses was much less than it is at present; and he supposes the cause of this difference to be a continental elevation, similar to that now taking place in Scandinavia—an elevation quite distinct, however, from that which caused the eastern Alps to appear, since the "diluvium," although raised, is not dislocated, nor have the rocks supporting it suffered any great contortions since its deposit.

Sir Roderick Murchison has discussed the whole question of the character and distribution of the superficial detritus of the Alps, and believes that the physical phenomena of the Alps and Jura are such as to force the geologist to restrict the former extension of glaciers in that country within very much narrower limits than Agassiz, Charpentier, and Forbes had supposed. He shows, from the still

* Bull. Soc. Geol. France, tom vi. page 445.

existing remnants of the water-worn and water-deposited detritus which exist at considerable heights on the sides of the valleys, that water entered into those valleys, then at a considerably lower level (two thousand or three thousand feet) than now. It is asserted that, as each glacier is formed in a *transverse* upper depression, these glaciers have by their movements pushed their moraines *across* the longitudinal valley, and have not united to form one great glacier in it: and thus proving that not even the upper longitudinal valleys around Mont Blanc were ever filled generally with glaciers, he thinks it very easy to show that the lower and great trunk valleys of the Arve, the Doire, and the Rhone, have no trace of moraines, although they contain large erratic blocks irregularly dispersed; all the other detritus is more or less water-worn, and this to great heights above the present bottom of the valleys. He supposes, therefore, that the country of the Alps and Jura has undergone great and unequal elevation since the period of the formation of the earliest glaciers; and that these elevations dislodged great portions of these glaciers, "which floated away many huge blocks on ice," and "hurled on vast turbid accumulations of boulders, sand, and gravel."

All the detritus in the low and undulating region between the Alps and the Jura is water-worn, and does not any where occur as a true moraine, while the great granite blocks from Mont Blanc, which are found on the Jura, appear to Sir Roderick Murchison to have been translated there by ice floats, when all the intermediate country was under water. The surface of the whole country has since been much changed by considerable and irregular elevations.

In this general resumé of the prominent facts regarding the distribution of the detritus of the Alps, Sir Roderick Murchison has thus appealed, in explanation of the phenomena, to the united forces of glaciers and ice-borne materials.

Bearing on the subject of glaciers, we have had a very interesting communication from Mr. John Ball, on the former existence of small glaciers in a part of the County of Kerry. The author describes the phenomena observed in two or three places. On the side of Connor Hill, between Loughs Doon and Beirne, on the steep northern slope of Brandon Hill, above Lough Cruttia, and on the north-eastern side of Purple mountain, Killarney. The several facts were clearly given, and the supposed extent of the glaciers

pointed out, as evidenced by the heaps of detritus representing, according to Mr. Ball, the moraines formerly deposited by these glaciers. From the facts noticed, Mr. Ball concludes, that whatever may have been the climatal condition of this country prior to the existence of these glaciers, the mean temperature at that time cannot have been excessively low, nor such as could have admitted of any considerable extension of glaciers in the adjoining district; for the extent of this glacier at Lough Doon, even under the probably different conditions of elevation of the land above the sea at the time was, according to Mr. Ball, very limited indeed. And secondly, he considers that, therefore, the conditions which gave rise to these small glaciers, must have continued with tolerable uniformity for very long periods; as it must be difficult otherwise to account for the amount of matter in the moraines, considering the slow rate of motion of small glaciers, the limited surface of rock from which the fragmentary materials were to be derived, and the small proportion of those fragments which would be deposited on the lateral moraine.*

The phenomena of striated, furrowed, and smoothed surfaces of rock had been noticed, as occurring in the County of Kerry, many years since, first by Mr. C. W. Hamilton before this Society in 1843, when he exhibited some excellent illustrative sketches; subsequently, Professor Airy had at the Meeting of the British Association, at Cork, mentioned some instances in which similar scratchings had been observed by him. During the past year, Mr. W. C. Trevelyan, has stated, that he had noticed similar polishing and scratching of rocks in several parts of Ireland, as at Limerick, on the cliffs at Kilkee, and at Howth, near Dublin, where the Society will recollect I noticed their occurrence several years since. Indeed it is difficult to conceive how any one could visit some of the districts mentioned, as for instance, the County of Kerry, where the absence of any drift covering allows the surface of the rocks to be well seen, without being at once, and most forcibly, struck with the peculiarly well marked, and beautifully defined furrowing, polishing and scratching, which every surface of rock presents. There is, for instance, scarcely a square yard of rock surface in the neighbourhood of Glengariff, on which such striæ cannot be distinctly seen. The occurrence, however

* Jour. Geol. Soc. Dublin, Vol. iv. page 151.

of these scratchings, over such extended surfaces, at elevations, reaching to even 1,300 and 1,400 feet above the present level of the sea, and at every intervening level, until they are concealed by the water itself, under which they extend as far as can be seen, and the peculiar positions in which such scratchings occur, as I have myself pointed out at Bray Head and Howth, were sufficient to satisfy, at the first glance, any unbiassed mind, that they had not been produced by true glaciers. Mr. Ball, therefore, very justly lays but little stress on such evidence of former glaciers, unless it be found coupled with other proofs. And while, therefore, we are satisfied, that as regards these countries, there is no sufficient evidence whatever to lead us to admit, that either the entire of the surface of this island was at one time covered with a sea of ice, or that glaciers had that enormous extension which has been assigned to them; we are at the same time far from thinking that there have not been true glaciers of limited extent in some of our mountain valleys, which have left unquestioned proofs of their former existence. For directing our attention to some hitherto unnoticed cases of this kind, in which it is probable such small glaciers may have existed, we are indebted to Mr. J. Ball. I see no reason to doubt the probability of such having existed, although they unquestionably appear to me to have been extremely rare, and though many of the instances which have been quoted, have on closer examination been proved to have been of very different origin. The heaps of gravel in Glenmalur I have myself shown not to be moraines. The mass of materials at the entrance, to the valley of Glendalough, on which stands the group of ruined buildings for which it is famous, is another instance of a so-called moraine, but which is undoubtedly the result of the ordinary action of water in forming a bar, by heaping up the detritus brought down by the two streams which here unite, at or near their junction.

There is one point on which Mr. Ball strongly insists—the necessity of admitting the lapse of a long period, for the production of the phenomena presented to us, which is even much more forcibly impressed on us, while considering such masses of water-borne, and water-deposited materials, as that to which I have just alluded.

There is, perhaps, nothing more calculated to give us just conceptions of the littleness of our ordinary times and periods, as compared with the long story of the world, than the contemplation of such a

scene. Before us stand the now ruined remains of buildings, the epoch of whose erection is shrouded in the darkness of antiquity, of whose date we have no record—buildings raised with all the care and skill which the most practised architects of the time could bring to their construction, and designed, by their form, to stand as lasting monuments of the piety of their founders; buildings, too, which have been in a great degree protected by their sacred character, from suffering by the sacrilegious hand of the destroyer. Over their head many a century has passed, and left its withering stains upon their brow, and yet even their date, thus too distant to be reckoned with the accuracy of recorded fact, or classed among historical statements, even this long period will not suffice to be the unit by which we may count back the times and the seasons, during which the same laws of matter, and the same cosmical forces, which now rule the material globe, exerted their untiring sway, and to reach the epoch when that heap of water-borne masses, on which these ruins stand, was accumuated—the measure of the forces which gave it birth, and the lasting evidence of their direction and amount.

Into what a mere shred does the long web of man's existence shrivel itself, when thus exposed to the light of nature's records! What a lesson of humility ought we to learn from this contrast of the unerring decay of man's proudest triumphs, with the lasting destiny of nature's monuments! And yet this, too, but forms a mere page in the long history of former change, and serves but as the record, into which are collected the scattered fragments of the tales which tell of mountains once washed by stormy oceans, and of gorges which once formed the long shores of a troubled sea.

In connexion with this subject, we would allude to a paper by Mr. Charles Maclaren, on grooved and striated rocks in the middle region of Scotland,* a paper distinguished for its candid exposition of the facts, while the author's views are expressed with equal strength and determination. Mr. Maclaren points out the serious objections which many persons have urged against Sir James Hall's idea of such groovings having been produced by the passage of a wave or waves carrying fragments of rocks, gravel, and sand; and he conceives that no agent yet known but ice, or ice conjointly with

* Jameson's Journal, July 1849, page 161.

water, can explain the phenomena; and then proceeds to detail the appearances presented in the several cases of groovings which he has noticed, at nearly thirty different points, shewing that as should be expected, if such groovings were caused by ice-carried agents, the side of prominent rocks which faces the source from which such glaciers have been derived, is always the most grooved and polished. These groovings were also frequently found horizontal on a nearly vertical face, a position in which water-borne materials could not have produced them. Some very interesting cases are given, and well described; and while the author very justly and wisely concludes, that much remains yet to be done before adequate materials for a satisfactory theory are collected, he speculates on the probability of certain results. Thus, the rarety of occurrence of moraines is accounted for by the probability that during the rise and fall of the ocean, deposits of moveable matter, like these moraines must have been frequently swept away.

Mr. Maclaren supposes further, that it is established by the phenomena, that the nucleus of the great force which produced these groovings, or the common centre from which the agents moved, was in the mountains which extend from Lough Goil to Lough Laggan: on the north and west side of which, the striæ are seen to have been produced by an agent moving from the south and east, and on the south-east side, by agents moving from the north and west.

Though a most valuable contribution to our knowledge of the facts, like everything proceeding from Mr. Maclaren's pen, there yet appear to me some assumptions in this paper to which it is needful to allude, in order to guard against the possibility of mistake on the part of future observers. Thus, speaking of the rise and fall of the ocean-level, Mr. Maclaren says, "we have evidence in support of the alleged changes of relative level in the fact, that striæ and grooving certainly produced by glaciers on terra firma, are found covered by the old boulder-clay, which has been deposited from water, and which ascends to the height of 800 feet, at least, above the present seas." Now, Mr. Maclaren appears to have in this assumed two circumstances all-important in the consideration of this question—1st, that the groovings have been produced by glaciers on terra firma; and 2nd, that this grooving has not been cotemporaneous with, or the result of, the formation of the old boulder-clay. If these be

granted as facts, the whole question of the so-called glacial drifts is very much simplified; but these are in reality the very points in dispute, which are assumed as settled. Again, speaking of the smooth side of hills between Garelock and Loch Lomond, at an elevation of 2,400 feet, the author says, he had at the time he first noticed this no authority for concluding that glaciers ever attained the depth of 2,400 feet necessary to cover the ridge on the west side of Loch Lomond. "But this objection is now removed, as the able French geologist, M. Martins, has found traces of an ancient glacier in the Alps, 758 metres, (2,468 English feet,) above the bottom of the valley which contained it. There is no difficulty now, therefore, in admitting that a glacier might abrade the surfaces of the highest of these ridges." In what way, the circumstance stated by M. Martins, even granting it to be an established fact, could prove or support the notion of the existence of such a glacier in the Loch Lomond country, is not to me clear. That glaciers *might* abrade these ridges, no geologist would deny; but the probability of their having ever done so, is only to be proved or established by evidence derived from the district adjoining, and this evidence is no more confirmed by the occurrence of similar phenomena among the Alps, than would the statement of the occurrence of a peculiar kind of rock, (protogene, for example,) in one district, be established by the well known fact of its occurrence in the other.

Nor can the injurious tendency of viewing the phenomena of the so-called drift deposits, only in connexion with, and as illustrated by, the phenomena of glaciers in the Alpine country of the south of Europe, be too strongly insisted on. The area of the earth's surface covered by such deposits, the distribution and limits of that area, and the phenomena exhibited by these formations are all too large, and too general, to derive their elucidation from such a comparatively insignificant outlier, as it were, of the phenomena resulting from the action of intense cold, as occurs in the Alps; and the whole range of the Scandinavian phenomena must be grasped by any one who will fairly undertake the subject, as well as those of the glacial district of Switzerland.

M. Visse, in a brief notice of the erratic-blocks of the Andes, near Quito,* has referred to those "fields of stones," or immense trains or

* Comtes Rendus, 1849, March 5th, page 303.

deposits of large blocks, having unquestionably the same mineral structure as the rocks of the mountains adjoining, but at a great distance from them, and their superposition on clayey, or arenaceous deposits. These have already excited much attention; and they have been supposed to be large blocks thrown out by volcanoes. On examining them more closely, however, the author has shown, that they occur for the most part in regular trains, having a definite direction, and are traceable up to the mountains, where they invariably end in a distinct escarpement. The size of the blocks diminishes, as the distance from this escarpement increases: the bands or trains being much more distinct in the higher portions of their line. After a careful search, it is remarkable that the author could not find a single scratched block among them, while all the facts obviously showed, that these trains were not the result of volcanic eruptions.

Another communication to our knowledge of similar phenomena is the work of M. Eugene Robert, forming a portion of the results obtained by the French scientific expedition to the north, in 1835 to 1840. In this M. Robert gives an account of his studies of the last traces which the sea has left on the surface of the northern continents, especially in Europe.

To the results, which he had previously brought forward, and which he has reproduced here, M. Robert adds many others. He has found rocks exhibiting proofs of wear and polishing, from the level of the sea up to 1,170 feet above it: he differs entirely from all previous observers, in stating that the furrowings and striæ are always in the direction of the bedding or lamination of the rocks; and do not occur in granites; and he supposes them due to the greater facility with which the several laminæ degrade on exposure. And uniting with these observations, many from tropical countries as well, he thinks that the whole of these superficial deposits are but terms of one and the same series, and assigns to them all, a common origin; namely, the presence of the waters of the ocean during ages, on surfaces becoming successively less and less deep; and emerging one after the other, either by slight displacements of the ocean from one hemisphere to the other, or by the effect of partial or general liftings of portions of the crust. The presence of blocks he accounts for, by supposing them carried successively by floating

ice, their great development at certain points being due to the length of time elapsed, rather than to any other cause. The striæ, as I have stated, he attributes to the prolonged action of the sea, on the unequally resisting laminæ of the rocks. This latter statement forms one of the most remarkable instances of how completely a preconceived notion can blind the eyes of an observer, that we know of, for nothing can possibly be more perfectly established, nor yet more obvious on the most cursory examination, than that the striation, the polishing, and the furrowing, or grooving of such rocks, is completely independent of their lamination or bedding. Unfortunately such assertions raise a doubt about the truth or accuracy of all the other statements put forward by the author.

While the general question of the distribution of detritus by glacial action has thus engaged much attention, M. Collomb has considered the complicated movement of the larger erratic blocks, which form *tables* on the surface of the glaciers.* The formation of these tables is a phenomenon long known, but the peculiar motion of the blocks has attracted but little attention. These blocks are rarely found on the moraines mixed with other materials. The most beautiful tables occur scattered over the surface of the middle of the *mers de glace;* they are met with isolated, as if thrown at random far from the moraines—they stand alone independent of the long trains of debris, which follow so remarkable a line on the surface of the glaciers. Now these facts of their distance and separation from the other debris, arise from the complication of their movements. This can be divided into *two* parts—one due to the general motion of the glacier itself, the other to that of the block. The author shows, that in proportion as the " table" is elevated from the general surface, the sun acts with greater force on the south side of the block than on the north, which is kept in the shade; and so the supporting ice being dissolved on that side, the tendency of the block, when about to fall, will always be to fall to the south. The motion is in fact double; on the one hand the block is carried by the general movement of translation of the glacier; on the other hand, its own peculiar motion consists of a succession of slips, which complicate the result. Thus a block can form a "table," several times during the

Bull. Soc. Geol. de France, tom. vi. page 161.

same summer. The removal of the surface of the glaciers in the Alps, in their lower portion, is about four metres in the year; while the height of the supporting column of ice of these tables is seldom more than two metres, so that a block can form a table at least twice in the same year.

Now this being the motion of the blocks, it is clear that if the general direction of motion of the glacier be the same,—viz., from north to south, the blocks must arrive at the terminal talus *before* the other materials; but if the glaciers have a motion in the opposite direction, or from south to north, then the reverse will be the case, as we must then subtract the motion of the table from the general movement of the glacier at large; or supposing the whole motion of the glacier to be fifty yards, and the block to make two slips or falls of two metres each, we would in one of the supposed cases have an actual movement forward of the block, amounting to fifty-four metres—in the other case to only forty-six. It follows also, from this peculiar motion, that a block can start from one bank of a glacier, and after a few years arrive at the other, (provided it does not meet during its progress, with any of those accidents common in glaciers, such as large crevasses or high moraines.) Since if the glaciers have a direction of motion from east to west, or west to east; the line of motion of the blocks will be a resultant of the two rectangular motions, proportional to the mean movement of each of them in a given time.

The author shews also, how the character of the surface as to inclination, and as to exposure, will materially modify such results: and then points out the application of these to the phenomena of erratic blocks, and as tending to explain the exceptions to the general law which M. M. Charpentier and Guyot have established—that the materials are distributed each in their own province; and some cases, where we find larger blocks of foreign matter mixed with the smaller debris. He shews also, the importance of not taking these large blocks as points of observation, in any attempt to determine the motion of glaciers, giving instances in confirmation.

Lieutenant Strachey has brought together many new observations, and compared them with the previously recorded ones, to determine the height at which the limit of the belt of perpetual snow is found in the Himalaya range.* This phenomenon, though not strictly

* Jour. Asiatic Society, Bengal, April, 1849.

geological, becomes to the geologist a very important element in the consideration of the speculations and reasonings which frequently engage him, as to the distribution of heat on the globe, and the consequences of variation in this distribution. Humboldt had already stated the interesting fact, that while on the southern slope or declivity of the Himalaya, the limit of perpetual snow was about 13,000 feet English; on the northern aspect in was 16,600, attributing this greater elevation of 3,600 feet to the conjoint effect of the radiation from the elevated plains of Thibet, and the comparatively unfrequent formation of snow in cold and dry air.

After discussing all the observations, Lieutenant Strachey concludes, that Humboldt has understated the height of the snow line; that it is on the southern side of the chain, 15,500, while on the northern it is 18,500, and that this is chiefly caused by the fact, that a much smaller quantity of snow falls on the northern slopes of the mountains, the winds prevalent there being from the south, which passing over the snowy peaks, become cold and unable to support moisture. Lieutenant Strachey thinks that the radiation from the plains of Thibet has little to do with it, as its effect would be, he thinks, entirely intercepted by the outer flanks of the chain. Captain Cunningham, however, has pointed out, that Humboldt was probably correct, in attributing the difference in elevation, partly to radiation; and that the form of the surface in any great chain is a more important consideration than the latitude, as the snow line constantly recedes, as the ground around the flanks of the chain rises, but with a constantly diminishing rate of difference.*

In connexion with the important subject of the extent, kind, and force of tidal action in modifying or producing deposits of varied character, I cannot forbear referring to a most valuable communication on the Tides of the Irish Channel, by Captain F. W. Beechey,† although not strictly within the range of this address, as the paper was published at the close of the year 1848. This is unquestionably one of the most important contributions to our knowledge of the tidal phenomena of the Irish channel, more especially as these bear

* Jour. Asiatic Society, Bengal, July, 1849.

† Phil. Trans. London, 1848, page 105.

upon geological investigations, that we have had for many years. And although to us, as geologists, this portion of the paper of Captain Beechey may, of course, be considered the most interesting, yet his observations are not without their great value in a commercial point of view, also, as tending most materially to facilitate the navigation of our seas, both by correcting erroneous ideas hitherto prevalent, and by furnishing accurate and sufficiently detailed data for future navigators. In this respect, one of the most interesting of his results is, that the time of the stream is simultaneous, notwithstanding the variety in the times of high water; that the northern and southern streams, in both channels, commence and end, practically speaking, in all parts at the same time; and that this time happens to correspond with the time of high and low water at Morecambe Bay, or Fleetwood. Thus, while it is high water at one end of the channel, it is low water at the other, the same stream making both high and low water at the same time. There are two spots in the channel, in one of which (near Courtown, County Wexford,) the stream runs with considerable velocity, although there is no perceptible rise or fall of tide, and in the other of which (off Dundrum Bay,) the water rises and falls from sixteen to twenty feet, without there being any perceptible horizontal motion.

I cannot possibly detain you by entering into the details of Captain Beechey's paper, in which he describes so graphically the course of the tides as they enter the Irish Channel, both from the north and south, noting the rate of rapidity of the water at the several prominent points. When the detailed charts of these observations shall be published, the connexion of this rate of motion with the character of the sea bottom at distant and varied parts of the channel, will be a question of great and important interest, of which Captain Beechey gives a glimpse in the few facts of the kind he has stated, as, for instance, the fact that the bottom of the space in which there is no perceptible motion, coupled with a considerable rise of tide, (a space of considerable extent between Dundrum Bay and the Calf of man,) is composed of soft blue mud. And another very remarkable fact, that the great body of the northern tide pressing more heavily on the Wigtonshire coast than on that of Antrim, has, in Captain Beechey's words, "*scooped out a remarkable ditch upwards of twenty miles long, by about a mile only in width, in which the depth is from* 400

to 600 feet greater than that of the general level of the bottom about it." Now, whether we fully admit with Captain Beechey, that this has been actually produced by the tidal action, or only suppose that some previously existing valley or depression is by that action kept clear of any deposit, in either case, the geologist will at once recognise the application of such well established facts to his enquiries or speculations regarding the forces which may have produced similar phenomena at earlier periods. And I know of no more fertile subject than this very consideration would open up for any one having time at his disposal for such enquiries; thus, to trace out, by the combined aid of geological and physical researches, the resulting modification as regards tidal action, which must necessarily have arisen from the remarkable and thoroughly established changes of level of land and sea, even in the most recent geological epochs. So early as 1844, I had the pleasure of being the first to lay before this Society maps, in which I had endeavoured to show, roughly, the most remarkable, and at first sight almost incredible, alteration in the general aspect of our seas, which even a change of level of 500 feet in this island would produce; and of pointing out, though briefly and imperfectly, some of the remarkable alterations which from such change must have resulted in the prevailing course of the tidal waters. But I am sanguine enough to hope that, by such enquiries carried out with greater detail, and with the aid of additional data since acquired, some of the remarkable facts relating to the distribution of the more recent deposits in Ireland (those which the French denote *terrains meubles*,) may be reduced to general laws; that precisely as we can now see the cause of the heaping up and accumulation of sandy-banks into Morecambe Bay, so will we be able to trace the general currents, and the direction and force of these currents, which have produced similar accumulations at former periods; and that in this as well as in all other branches of geological investigation, we may much more philosophically and simply explain the phenomena, by a reference to known and existing forces and laws, than by having recourse to any speculation as to enormous climatal changes, or the operation of mighty forces, the former existence of which, to say the least, is doubtful. And to Captain Beechey, I think, geologists are much indebted for the contribution to the data necessary for such enquiries, which his paper affords.

I do not refer to the many other points discussed by Captain Beechey with equal ability, such as the position of the mean water level, the curve or outline of the surface of the tidal wave at different parts of its course, and on different sides of the channel; and the unequal motion of the upper and lower half of the tide wave. These, though they are all points of great interest, do not so immediately bear upon geology.

We would also refer to a very valuable and interesting communication on a similar subject, from Mr. R. A. C. Austen, on the valley of the English channel,* read to the Geological Society of London, in June last. In this Mr. Austen has applied his knowledge of the soundings and bottom of the channel, with great skill, to determine the distribution of materials in that channel, and from this to argue back to the former outline of coast, and afterwards to determine the period of the formation of the channel. I regret much that the details of this paper have only been published within the last few days, so that I am unable to refer to them as fully as I could have wished, and as their great interest to geologists demands.

M. Perrey, to whose continued labours in bringing together, as far as in his power, a complete list of all observed earthquakes, we alluded fully last year, has since published,† in continuation of former lists, one of all the earthquakes which he has found any notice of as occurring in the year 1848. The political and social disturbances so general during that year appear to have prevented many from being recorded. The total number does not amount to more than fifty; of these, the direction of the oscillation of only eleven is given; and the mere fact of a trembling having been observed is in many cases all that has been recorded. The same author has also prepared a list of the earthquakes observed in the United States and Canada, not yet, however, completed. We have also some notices of earthquakes in Assam‡ which appear to have come from the north. The sound wave, was in some cases heard very distinctly three seconds before there was any disturbance of the ground.

The comparative uselessness of such observations, I had occasion

* Quar. Jour. Geol. Soc. No. 21, page 69.

† Bull. de l'Acad. Royale, Bruxelles, 1849, page 228.

‡ Journal, Asiatic. Soc. Bengal, Feb. 1849, page 172.

to insist upon last year, and the necessity for more accurate and systematic observation of earthquake phenomena, is daily becoming more obvious. With this increased necessity, however, we have had increased facilities, and greatly improved methods pointed out. Mr. Mallet has furnished to the British Association during the past year, a very able and detailed report on the statical and dynamical facts of earthquakes, in which he has discussed the several theories of their origin, and clearly enunciated the several conclusions which he considers himself entitled to draw from a review of the whole, supporting each by the details of the cases on which it is founded. As bearing immediately on geology, we will just notice the important conclusion, which necessarily follows from the fact established by Mr. Mallet that the shock or earth-wave is a true undulation of the solid crust of the earth, that earthquakes, however great, are *directly* incapable of producing any permanent elevation or depression on the surface of the earth. *Indirectly*, or by their secondary effect, they may, as by causing land-slips—forming new lakes or river courses—producing fissures, &c., or by the great sea-wave which occasionally results, and which acts with enormous power on the coasts.

Mr. Mallet also discusses the relation of the weather, the state of of the thermometer, barometer, &c., to earthquakes both before, during, and after the actual shocks; and points to the want of correct experiments on the elasticity of the substances forming the earth's crust, and on the rate of transit of the shock through known materials. Mr. Mallet has since been conducting some well devised experiments to determine the latter points, and I believe, with results of great interest. These are not, however, as yet published. I must however, refer to his admirable little essay on the same subject, forming one of those included in the Manual of Scientific Enquiry, published by the Lords of the Admiralty, in which many excellent and simple devices for earthquake observations are pointed out, and clear succinct directions given on points requiring elucidation. And we shall look forward with great interest to the completion of Mr. Mallet's reports and experiments.

Our *palæontological* acquisitions during the past year, have been numerous and interesting. The knowledge already acquired of the forms of organized creatures, of which remains exist in the fossil state, and the comparatively accurate acquaintance with the forms, structures, and habits of existing organisms, which naturalists have obtained during the last few years, have, however, necessarily exerted a very obvious influence on the *character* of such additions to our knowledge; and while we are constantly having new species, or new genera established, or the history of the development of old and well known ones elucidated; while additional facts are being acquired, bearing on the distribution of these genera, whether viewed geologically or geographically, we cannot expect, nor should we look for, such general and striking results, as in the earlier epochs of the history of geology astonished and captivated its students. These great generalizations, essential as they were to the progress of our knowledge, must continually be subject to slight and ever-varying changes, in proportion as we become more accurately informed on the details of our enquiries; and thus it is, that the prominent features being sketched in, it is now the duty of the geological investigator to seek out the minute details, to range these details, each in its peculiar and proper order, and thus, as it were, to bring together and group into general results the statistics of our science. Now though every branch of our enquiry opens up a wide field for the application of this mode of reasoning, and though we are fully satisfied that many important results would be obtained by a more strict and searching reduction to numerical tables of the facts connected with the distribution of minerals, metals, &c., still there is no branch of geological investigation which is more obviously adapted to such methods, than that which concerns itself with the number, variety, and distribution of the forms of organic life, in the several geological groups of stratified rocks. So obvious, indeed, is this, that many writers have already devoted themselves to the collection and collation of such numerical aggregates, and important and valuable results have been obtained.

It may be objected to such enquiries, that with the present imperfect state of our knowledge of the facts of distribution, or even of identification of species or genera, any general results obtained from such imperfect data, must themselves be imperfect. And this is unquestionably true, but true only to a certain extent.

The imperfection of our knowledge on these points, arises from several causes; one of these in the imperfect state of preservation in which the fossils are found. This source of error can readily be eliminated, by rejecting from our calculations all such species as have been named or determined upon such insufficient data. But such cases are extremely few, as compared with the whole number; and a much more fruitful source of error is, that in the majority of cases, the remains of plants or animals, from two or more distinct localities have been identified or described by two or more distinct observers; and we have thus a most important "personal error," introduced into our observations. The chances of this error are happily becoming every day less and less, from the frequent interchange of specimens and opinions among geologists; and this has now been done so frequently and so carefully, that although there undoubtedly are still in our lists of fossils, very many called by different names by different persons, while the fossils themselves are in reality the same, still the total number of such, as compared with the total number of known and acknowledged species, must be represented by a very small fraction indeed, while the rest, forming by very much the majority of the whole, remain as sound and unquestioned data on which the palæontological statist can found his enquiries, and from which he can deduce his results. In several groups, the investigation of which has been specially undertaken by individuals, to whom access had been afforded to the best collections in all countries, the number of such species described under various synonymes by different authors, is very small; as, for instance, in the case of fossil fish. But even taking the group, in which the greatest amount of such confusion is acknowledged to exist, and in the conchylia we have not more than 0.10. to 0.20. which rest under this confusion. Another great difficulty in such investigations, consists in this, that we do not accurately know even the present creation; and still more, that even granting that we know the fossils already discovered perfectly, these said fossils only represent a small portion of the whole which once existed.

In this point of view, the most important contribution of the last few years, has been the very laborious and detailed work of Professor Bronn, in his *Geschichte der Natur*. The amount of labour and detail which he has brought together in this, may be estimated

in some degree from the total number of fossil species which he has enumerated, being 26,421; and in his general tables he has grouped these among the several formations in which they are found, and the several natural history classes to which they belong. It would clearly be impossible in an address like the present, to give even a rude idea of such results, and we must therefore refer to the original work.

Professor Bronn has further taken up some other questions, as the results of these enquiries, and discussed them with some detail. One of these is the "*duration of species,*" *(Dauer der Arten.)* After enumerating many cases in which species are known to pass from one formation into another, or even into two or more other formations, he shews that while the duration of species taken singly, may be very varied, still the average or mean duration may be obtained from a large number of such cases; thus as the general result, it is found that out of

	2,055 plants,	12	= 0.06.	Species pass into other formations.
	24,366 animals,	3322	= 0,134.	
Total	26,421	3334	= 0.124.	

Or allowing for the fact that in this the numbers for the plants are too small, and for the animals probably too large, owing to causes which the author points out, he deduces the conclusion, that each species has had an average duration of less than 1.12 formation; remembering at the same time that the occurrence in any one period does not represent an occurrence through the whole of that period, but on the average for a much shorter time. Taking the question of duration of the genera, it appears that there are several limited to a single *formation,* others to a single *period,* consisting of several formations, while others pass through several periods, and some exist at present.

			In different Periods.	Formations.	
Thus of	350	genera of plants,	463	592 times	= 1: 1.32: 1.69
	2501	„ animals,	3347	5415	= 1: 1.34: 2.17
Together,	2851		3810	6007	= 1: 1.34: 2.11

Or in other words—out of 100 genera, 34 per cent. pass into a second period; and 100 genera of plants occur in different forma-

tions, 69; 100 genera of animals, 117; or of both taken together, 211 times.

The author then considers the very interesting question of the number of the species, *(Zahl der Arten;)* or as he puts it—whether (admitting that the actual proportion of the separate divisions of the organic kingdoms to each other has obtained so long as these divisions themselves have existed,) it be possible from the number of still living species to estimate the number of all that have ever existed: in this enquiry, calculating from the number of species preserved in the easily preservable classes, orders, &c., to the number which may have existed in those more dificult of preservation: from the number of parasites, the number of organisms on which they lived, and *vice versa:* supposing a numerical proportion, similar to the present, to have existed between the several groups from their first appearance up to the present period.

Now this proportion of the fossil species to living is thus:—

	Fossil.	Living.	Fossil and Lving.	Proportion.
Plants,	2,050	70,000	72,050	3 : 100 : 103
Animals,	24,000	100,000	124,000	24 : 100 : 124
	26,050	170,000	196,050 =	15 : 100 : 115

that is taking the numbers in round sums, and allowing a little further reduction to be introduced from imperfect specimens, or want of proper identification introducing synonymes.

From this we see, that the number of living animals is not much greater than that of living plants—the proportion being 100 to 70; while the number of fossil animals bears the proportion of 100 to 9 to fossil plants. It must, however, be admitted, that such a proportion, one so widely different from that now existing between these two groups, which have such an important and acknowledged reciprocal influence, one on the other, never existed, and their absence must be due to their being comparatively so difficult of preservation.

In order, however, to follow out the calculation here indicated, it becomes essential to establish first of all, the number of formations which in a palæontological point of view may be considered as reciprocally *equivalent* or of equal value. Professor Bronn assumes of these fifteen, in the whole series. Now though it was previously seen that 12 per cent. of the fossil species passed from one forma-

tion into another, still it must be remembered that by far the larger proportion only continued for a portion, or even a small portion of the duration of that formation; so that estimating all these changes, generally speaking gradual, occasionally sudden, it may fairly be concluded that the mean average *life of a species* was equal to one-half the time of a formation; or in other words, that there have been during the formation of the whole known series of stratified rocks, thirty changes of species, or thirty times the duration or life of a species *(= 30 Arten-wechsel, Arten-dauern, and Arten-Alter setzen.)* Again, in endeavouring to ascertain whether at former periods the earth was as fully or as numerously peopled with species as at present, it is obvious that we can only obtain a fair result by comparing not the entire fossil flora, or fauna with the present, but the fossils of some one locality, (the circumstances of which were favourable for their preservation, and the rocks of which correspond to the duration of a life of a species, or in other words, form a portion of a formation,) with the existing fauna and flora of the same locality; and then combining several such local results, arriving at a general conclusion. Professor Bronn gives instances from all the principal groups of rocks bearing on this question, for the details of which, however, I must refer you to his valuable work, and he concludes from these that although all classes, orders, or families, may not have at all times existed on our earth, though some few groups of them may have vanished, yet that those which then existed were at all times as numerously represented by genera and species as at present. At the same time this did not exclude greater or lesser variations, both in horizontal and vertical direction, and thus many groups might regularly and constantly be more numerously or less numerously represented than at present.

Thus, then, there have been—1st, at least thirty times on the globe a change of species, or thirty "lives of a species." 2nd, during each of these lives of a species, each group in the organic kingdom, which existed at that time, was as numerously represented in former times as now; and 3rd, that notwithstanding the variations and oscillations of several groups, the existing number of the species and genera of each group may be considered as unity, or as the equivalent of each life or duration of a species, *(Arten-alter;)* and these variations, *(Schwankungen)* may even be shown by an exponent placed after the number of existing species.

These exponents clearly cannot be taken with perfect accuracy in the present state of our knowledge; but Professor Bronn has established provisionally for each group its exponent, acknowledging that in some cases it is too high, in others too low; and he thus obtains a general view of the duration and number of the various groups during all geological time. He thus obtains in round numbers 1,500,000 species of animals, and 500,000 species of plants; and it will not in the slightest degree affect the accuracy or the originality and value of Professor Bronn's *method* of arriving at this result whether future corrections increase or diminish this total. Of the 2,000,000 species thus estimated to have once existed, probably not $\frac{1}{10}$ or 200,000 were such as to leave their remains imbedded so as to be recognised, and even of these 200,000, a large portion will never come to our knowledge.

Professor Bronn then enters on the question of the relative richness in fossils of the several periods, (Carboniferous, Triassic, Oolitic, Cretaceous, Tertiary,) into which he divides the whole series. As regards their absolute richness in fossil species, they would stand thus according to

Plants, Cretaceous, Triassic, Oolitic, Tertiary, Carboniferous.
Animals, Triassic, Oolitic, Carboniferous, Cretaceous, Tertiary.
Together, Triassic, Oolitic, Cretaceous, Carboniferous, Tertiary.

He points out fully the difficulty also of saying which period, estimated from time of equal length, was richer, from the many disturbing causes to be considered in the calculation, and from our absolute ignorance as to the existence or non-existence of an uniform proportion between the time and the causes that destroy species, and some other considerations.*

This very brief analysis of some of Professor Bronn's results, will, I hope, be sufficient to indicate the value and importance of his labours. As a work of reference for the student, it is one of the most useful that have issued from the press, and has, as it were, completed for the whole series of fossil organisms, what a monograph on any detached group accomplishes, by bringing together detached and isolated notices, and rendering them all accessible at one view.

* Neues Jahrbuch. Leonhard and Bronn. 2nd Heft, 1849, also since translated by Professor Nicol, in Quar. Jour. Geol. Soc. London. No. 20, Nov. 1849, page 30.

But the work itself must be in the hands of every palæontologist, and I need not impress on them its great value and interest.

If we adopt the plan of grouping the several palæontological contributions, published during the year by the geological succession of the groups of rocks to which they most particularly refer, among the first we would place the fragment of his larger work on the silurian system of Bohemia, which M. Barrande has given us, in which he treats at full, of the successive steps in the development of the species which he had originally (1846) named *Sao hirstua.* In this memoir,* he satisfactorily points out the several stages through which this crustacean passes, the changes in its form, and in the number of rings, or thoracic segments, which are only three in the young state, but increase as the animal grew. The cephalic shield in the young animal constitutes nearly the whole animal, but forms a very small portion of the adult; and so great are these metamorphoses in form, that it is scarcely to be wondered at, that previous writers had classed the several stages under different species, and even genera. In fact, Barrande has reduced to the one species of Sao hirsuta, no less than twenty-two species described under thirteen different genera.

These metamorphoses have a remarkable interest also for the physiologist, bearing on the question of the affinities of these crustaceans as indicating their embryonic state ; and judging from this fragment of his larger promised work, M. Barrande's labours will, doubtless, throw much light on the fossil history of the earlier geological epochs.

During the past year, two decades of fossils have been published in connexion with the Geological Survey of the United Kingdom, one of which (No. 2,) is devoted to trilobites ; and here also we have a notice of a somewhat similar metamorphosis in another genus of this interesting class. Mr. Salter has observed in the species which he has named *Ogygia Portlockii*, that the youngest specimen found has only four thoracic rings, while others more fully grown have seven and eight. We may be allowed here to direct attention also to the extreme beauty and accuracy of the illustrations published in these decades, in the engraving of which, advantage has been taken of the facilities afforded by the modern improvements in steel engrav-

* Leonhard and Bronn, Jahrbuch, 4th part, 1849, page 385.

ing, so that the most perfect effects of tinting is produced, while the lines employed to produce the effect of form, do not in the slightest degree interfere with those used to represent structural markings.*

Mr. M'Coy, in a paper on the classification of British fossil crustacea, &c., has not only described several new genera (*Chasmops, Trimerocephalus, Barrandia, Tretaspis, Harpidella,*) and species of trilobites, but has also given some general views on the classification of the whole family. As the chief ground of his subdivision he takes the character of the *pleuræ,* or lateral portions of the thoracic segments; and he adopts five sub-families to include the whole group. Taking into consideration the remarkable facts we have just noticed, as established by the researches of Barrande on the metamorphoses of trilobites, it may fairly be questioned whether many of these divisions will not be necessarily modified by the progress of investigation, although such changes will not detract from the present value of these classifications.

Mr. M'Coy has further examined the homologies of the cephalic portion of trilobites, and the much discussed "facial suture." He considers the cephalic shield as composed of an extension of the two first cephalic rings, the facial suture itself being the line of separation between the first and second cephalic ring—the portion bearing the eyes, or that anterior and external to the eye line, being the first or opthalmic ring, as in other crustacea. Such is Mr. M'Coy's view, in support of which there is much to be said, although there are also several important difficulties in admitting it. The character of the *pleuræ* is also more fully described than they have hitherto been, and they are divided into two groups—facetted and non-facetted, the *facet* being "the smooth flat triangular space at the extremity of the anterior margin of the pleuræ of certain trilobites." The paper also contains valuable remarks on some other families of crustacea besides the trilobites.†

M. Marie Roualt, has described and figured a new trilobite of the genus Lichas (*L : heberti*) from the schists of Vitre, in Britanny, in which he announces the discovery of *Homanolotus, Ogygia, Illænus,* &c.‡

* Memoirs of the Geological Survey of the United Kingdom. Figures and descriptions illustrative of British organic remains. Decade 2.

† Ann. Nat. History, Dec. 1849, page 392, &c.

‡ Bull. Soc. Geol. de France, March, 19, 1849, page 377.

Mr. Fletcher of Dudley, whose very beautiful and perfect collection of the fossils of that neighbourhood is well known, has recently described some species of Lichas from Dudley.*

Mr. Davidson has added to his former valuable descriptions of the Brachiopoda, figuring a new species *Leptæna grayi*. He questions further the propriety of grouping under one species, (as Mr. Salter had done,) *Orthis rustica, walsali*, and *calligramma*, thinking, with M. De Verneuil, that *O calligramma* does not occur in England. In the same paper he describes a new species, *Leptæna granulosa* from the marlstone of the lias near Ilminster, found associated with *Terebratula pygmæa*, which latter also occurs in France associated with *Lep : liassiana*. This is an interesting discovery, and with the other species already described from the lias, (viz. *Leptæna liassiana, bouchardi, moorei, pearcei*,) prove that the genus leptœna, supposed to have died out with the palœozoic rocks, has really continued to exist, although in small number and of minute size, in the newer deposits.†

Professor M'Coy has described a considerable number of new Palœozoic Echinodermata, principally derived from the carboniferous limestone of Derbyshire and Yorkshire. We have to regret the absence of any figures of the fourteen new species established, some of which are, however, well marked and will be recognizable.‡

Sir Philip Egerton has continued his valuable additions to our knowledge of fossil fish. In his Palicthyologic notes, (No. 2,) he proved that the genus Platysomus of Agassiz must be classed with the *Pycnodonts*, not the *Lepidoidei*, and that the *globulodus* of Münster is a true *platysomus*, so that his genus must be cancelled.§ And in No. 3 of his notes, he has given a general survey of the heterocerque ganoids—describing and figuring some new species.||

M. L. Abbé Danielo has found vast numbers of the curious, and hitherto little known remains, called *bilobites* by Cordier; and he has come to the conclusion that they are distinctly vegetable. They occur in beds associated with others containing Arca, modiola, tere-

* Athenæum, Jan. 19, 1850.

† Bul. Soc. Geol. France, tom vi. page 271, Feb. 5, 1849.

‡ Ann. Nat. Hist., April, 1849, page 244.

§ Quar. Jour. Geol. Soc. London, 1849, page 329.

|| Quar. Jour. Geol. Soc. London, 1850, page 1.

bratula, &c., and which he considers to belong to the Devonian groups, in the department of Morbihan.*

Mr. Morris has announced the discovery of a species of Siphonotreta, (*S. anglica*, Morr,) in the Wenlock shale of Dudley.†

The discovery by Mr. Isaac Lea, of the foot-prints of reptiles in the old red sandstone at Pottsville, Pennsylvania, consisting of six distinct markings in a double row, is another very interesting addition to our knowledge of the distribution of animal life in the stratified rocks. Until very recently, as you are aware, no reptile forms had been observed in any rocks older than the Permian group, but Goldfüss had found two skeletons of reptiles in the coal formation near Treves; and Dr. King, in America, had also found foot-prints of a reptile in the western coalfield; and now Mr. Lea has shewn the existence of these air-breathing animals at an earlier period in the old red sandstone epoch. He proposes to name the animal whose tracks upon the sand are thus so wonderfully preserved—*Sauropus primævus*.‡

In connexion with these foot-prints we would notice an elaborate and detailed account of all hitherto described, illustrated by numerous plates—(128 pages, and 24 plates,) by Professor Hitchcock, President of Amherst College. He describes fifty-one species in all—of which twelve are quadrupeds, four of lizards, (?) two chelonian, six batrachian, two mollusca or annelida, thirty-four bipeds, three doubtful.§

Mr. Binney, who has already contributed so much to the history of those remarkable fossils, the *Stigmaria* and *Sigillaria*, has more recently found Stigmaria, in the middle of a seam of coal, full of the spores of the lepidostrobus, an important and additional fact in their history, as bringing the two together. It may be remembered, that in the case of the Dixon fold trees, described by Mr. Bowman, and which were by him considered to be Sigillaria, there were numerous lepidostrobi lying around their roots. Mr. Binney's specimens were derived from the so-called "brasses," or lumps of iron pyrites, which abound in the "King coal" at Wigan, and which have to be picked

* Comtes Rendus., 26 March, 1849, page 415.

† Athenæum. Brit. Ass. Report, page 992.

‡ Brit. Ass. Report. Athenæum, page 937, 1849.

§ American Academy Transac., Boston, 1848, vol. iii., 2nd series.

out before the coal is sent to market. In the centre of these "brasses," Mr. Binney frequently found a stigmaria, composed of clay ironstone, generally much compressed, but occasionally so preserved as to exhibit their original round form, and their structure. Mr. Binney also states, that after careful examination of many specimens in situ, he has not been able to confirm the idea of their being a true *taproot* to Sigillaria.*

In this latter circumstance, Mr. Binney differs altogether from Mr. Brown, who has described some erect Sigillaria with roots in situ, found in the roof of the Sydney Main coal, in the Island of Cape Breton; the stem, and roots attached, were found in their place of growth, rooted in a bed of hard shale covering the coal. On carefully clearing out the under surface of the fossil, Mr. Brown found that the horizontal roots branched off in a very regular manner, the base being first divided into four quarters, by deep channels running from near the centre outwards—(the "crucial suture" of J. Hooker?) an inch or two further from the centre, these quarters are again divided into two roots which themselves bifurcate again, so as to produce thirty-two roots in all, within a circle, in Mr. Brown's specimens, of eighteen inches diameter. In each quarter of the stump, there were four large tap roots, one on each rootlet, and beyond these, about five inches, another set of smaller tap roots, so that there were forty-eight in all—viz., sixteen in the inner circle, and thirty-two in the outer. Mr. Brown points out the curious correspondence between the number of the roots, (thirty-two,) and the vertical rows of leaf-scars on the stem, (also thirty-two,) and infers from the character of the roots, and their peculiar position with regard to the beds of shale and coal, that the plants to which they belonged were adapted for living in a soft muddy soil. He also shows that the remarkable "dome-shaped" fossil figured by Lindley and Hutton, is nothing but a similar root of Sigillaria, with the stem broken off.

The roots of these large sigillariæ were found not to cover an area of more than thirty square feet; while the roots of lepidodendron, which the same author previously described, and whose stem was only two or three inches in diameter, covered an area of two hundred square feet. Now the lepidodendron were lofty trees with spreading branches; and he concludes from this proportion in

* Quar. Jour. Geol. Soc. London, Feb. 1850, page 17–21.

the size of their roots, that sigillariæ were, on the contrary, trees of low growth, and without spreading branches.*

A very important contribution to the knowledge of fossil fish has been made by Mr. W. C. Williamson, in his memoir on the microscopic structure of the scales and dermal teeth of some ganoid and placoid fish.† After reviewing the opinions held by previous investigators, Mr. Williamson gives the result of his examination of the scales of the genera *Lepidosteus*, *Lepidotus*, *Seminotus*, *Pholidotus*, *Ptycholepis*, *Beryx*, and *Dapedius*—all of which seem to be constructed after one common type, with modifications. Another group of structures was found in *Megalicthys*, *Holoptychius*, and *Diplopterus*. Many others were also examined, and the structure of their scales is given in detail, and very fully illustrated. The author concludes from all, that what has hitherto been called enamel, is in fishes a compound structure, separable into two—ganoine, and what he calls kosmine; the former being superficial, transparent, and laminated, but otherwise without structure; the latter consisting of minute branching tubes, resembling the dentine of true teeth;—that the kosmine covering the osseous scales of many ganoid fishes is homologous to, and identical with, the substance forming the dermal teeth of placoids, so that the distinction of ganoid and placoid can scarcely be retained as a physiological one; and that the ganoid scales consist of variously modified osseous lamellæ, successively added chiefly to the lower surface, but also occasionally to a part or the whole of the upper surface. He shows also, the mode in which these lamellæ have been formed, and points out the advantage of using the microscope as a means of distinguishing genera and species, and also of establishing their affinities, wisely cautioning against the danger of urging such investigations too far, without giving full weight to the importance of the other portions of the fish to which these scales belong.

As connected with the palæontology of the older rocks, we must also refer to the publication of the geological investigations of the American exploring expedition, illustrated by a large folio volume of plates. Many of the fossils figured have been already described

* Quar. Jour. Geol. Soc. London, 1849, page 354.

† Phil. Trans. London, 1849, page 435.

by Count Strzelecki and others; but the work contains also numerous additions to those previously published.

M. Bayle has announced the occurrence in the well known beds of Saint Cassian, of a mixture of palœozoic and mesozoic species; of fishes, there are species of Gyrolepis, Hybodus, &c.; of cephalopoda —Orthoceras, Goniatites, Ceratites, Ammonites; also Bellerophon, Porcellia, Nucula, Trigonia, Terebratula, Spirifer, Producta (leonhardi) Cidaris, &c. He considers the beds as an intermediate term, belonging, however, to the *marnes irisees.**

The fossil fish of the Muschelkalk of Jena, Querfurt and Esperstädt, have been described by Von Meyer, who has also published the fish, crustacea, echinoderms, and other fossils of the same rock, at Oberschlesien.† In this monograph, which is very well illustrated by finely drawn and neatly printed figures, he describes twenty species of fish alone, belonging to the genera Leiacanthus, Hybodus, Acrodus, Palæobates, Sauricthys, &c. &c.

The fossils of the Muschelkalk of north-west Germany, have been investigated also by Von Strombech, in an excellent memoir, published in the Proceedings of the German Geological Society. In this communicatiou, the important point of the distribution of the species is particularly attended to.

The fossils found at Spitzbergen, and referred by their finder, M. Eugene Robert, to the carboniferous group, have been shown by M. De Koninck really to belong to the Permian series, or the Zechstein. Among them were *Spirifer undulatus*, *Productus horridus*, *P. cancrini*. Some of the species of spirifer belong to the genus spiriferina of D'Orbigny, having their shells perforated; of which subgenus none have as yet been found in the carboniferous group.‡

Mr. Morris, whose accuracy and research are so well known to, and so highly appreciated by, all British palæontologists, has described a new genus of shells from the secondary strata, to which he has given the name *Neritoma*, differing from the true *neritæ*, with which they had previously been associated, in having on the outer lip two sinuses more or less deeply marked, and also in the

* Bull. Soc. Geol. de France, 5th March, 1849, page 323.

† Dunker ünd Von Meyer, Palæontographica, 1 Band V. lief, page 195—216.

‡ Comtes. Rendus, and Bull. Soc. Geol. de Francc.

form of the aperture and the columellar lip. Mr. Morris also points out the interesting fact, that this group of shells forms a distinct generic type, and adds another instance of molluscs, which, with analogous forms, have yet a distinctive character similar to Neritoma, in possessing a greater or less sinus in the outer lip. And in grouping such genera with their analogues, it is remarked that most of those which have this sinus belong to extinct genera. Thus *Acroculia*, *Murchisonia*, *Platyschisma*, found in the palæozoic rocks, are represented by the analogous existing genera without sinuses, of *Pileopsis*, *Cerithium*, and *Trochus*. *Neritoma* in the secondary rocks, by *Nerita* existing, &c.*

Mr. King, whose catalogue of the Permian fossils of Northumberland, &c. is in the press for the Palæontographical Society, has given a brief summary,† but without any illustrations, of some of the families and genera of corals of that group, describing six new genera. It is impossible to say how far such divisions are well grounded or not, until the details are given; and the very important changes which have been introduced in the classification of the coralline fossils, as more perfectly preserved or more numerous specimens have been examined, should render us extremely cautious in admitting any subdivisions which are not grounded upon sufficient data. In the group of corallines especially, it appears to me that great impediments have been thrown in the way of the progress of sound knowledge, by a heaping up of names of genera and species, most of them described from very small and, in many cases, imperfect fragments, which cannot possibly afford any information as to the habits of growth of the coralline, and but a very imperfect insight into its structure. I have had occasion years since to point out some instances of confusion arising from these causes, and am still even more convinced of the necessity of great caution, and the possession of good, and even numerous specimens, before venturing on any new classification of the forms found in the fossil state.

In connexion with Zoophytology in general, the extremely valuable, and ably illustrated papers of M. Milne Edwards and Jules Haime, which continue to enrich the pages of the *Annales des Sci-*

* Quar. Jour. Geol. Soc. London, Nov. 1849, page 332.

† Ann. Nat. His. May, 1849, page 388.

ences Naturelles, must be referred to as among the most important contributions to fossil Zoophytology, which have ever appeared.

The very remarkable and curious batrachians, known to geologists under the name of *Labyrinthodon*, have been beautifully illustrated by Burmeister, in a monograph on those found in the bünter-sandstein near Bemburg.

Dr. Lloyd has also described the remains of a new species, which he has named *Labyrinthodon Bucklandi*, from near Kenilworth, Warwickshire. The specimen exhibits a skull compressed between two layers of sandstone, and having twenty or more teeth in the maxillary bone. Dr. Lloyd thinks the bed in which this specimen was found is undoubtedly to be referred to the same subdivision as that from which Burmeister's specimens were derived—the bünter-sandstein; whereas those previously found in the same neighbourhood were from the white sandstone of Warwick, which has been rather uncertainly referred to the keüper.* Mr. Sanders, at the same meeting of the British Association, gave some reasons for considering that the beds in which the remains of the Thecodontosaurus and Palæosaurus were found at Durdham down near Bristol, belonged not to the lowest portion, but rather to the latest period of the new red sandstone.

In the first part of a paper, already referred to, by Professor M'Coy, we have some valuable additions to our knowledge of the structure and forms of fossil crustacea, from the newer secondary and tertiary rocks. In this communication, the Professor has formed eight new genera for the reception of these crustacea, and thirteen new species. Some of these being illustrated by well executed woodcuts, the paper forms an important addition to our knowledge of a group of fossils, frequently preserved with great perfection, and which have hitherto not received much attention from British palæontologists.†

Dr. Mantell has added considerably to our acquaintance with the structure of the wealden reptiles, in his description of some additional specimens of the *Iguanodon* and *Hylæosaurus*, the most important portion of which is the determination of the vertebral

* Athenæn. Brit. Ass. Report, 1849, page 992.

† Annals Nat. His. Sep. and Nov. 1849.

column, pectoral arch, and anterior extremities of the Iguanodon. The vertebral column presents the interesting fact of having the anterior dorsal and cervical vertebræ convexo-concave; that is, convex in front, and concave behind, (as in the remarkable reptile called *streptospondylus,)* but this convexity of the anterior side, or face of the body of the vertebra gradually diminishes, and it becomes flat in the middle and posterior part of the dorsal region. Dr. Mantell considers the vertebræ referred by Owen to Streptospondylus major, (British Association report on fossil reptiles,) to be in reality cervical vertebræ of the Iguanodon, and some of those referred to *cetiosaurus*, as being posterior dorsal, and lumbar vertebræ of the same reptile. The sacrum, the pectoral arch, and the humerus, are also described at length: and Professor Melville's able anatomical remarks are appended. It has thus been Dr. Mantell's good fortune, after the lapse of quarter of a century, to complete the description of the gigantic saurian, which he had himself first noticed from a few "isolated and water-worn teeth"—a well earned, and well merited reward of the untiring zeal and energy with which he has pursued his researches.*

M. Saemann, in some observations on the family of Rudista, has given the results of his careful examination of numerous specimens, (especially with reference to their internal structure,) of Sphærulites and Hippurites, and has perfectly established the existence of distinct hinges, and muscular attachment of a peculiar kind, which places the question of the classification of Hippurites, in which the structure of these parts was not previously known, beyond a doubt, and shows that they belong to the Ostracea, with which group Deshayes has previously ranked them.†

From M. Soriquet we have a complete list of all the Echinida found in the cretaceous group of the department de l'Eure, useful for comparison with other districts, all of these amounting to seventy-four species, having been determined on the high authority of M. Michelin. Of these seventy-four species, three only are stated to be common to the white chalk, and the *craie chloriteè*.‡

And from the Geological Survey of Great Britain, we have in the

* Phil. Trans. London, 1849, page 271.

† Bull. Soc. Geol. France, Feb. 1849, page 280.

‡ Bull. Soc. Geol. France, April, 1849, page 441.

first decade of fossils, beautiful figures and descriptions of a number of Echinoderms. Professor E. Forbes has here given all the known British silurian species of asteriadæ, some new forms of oolitic, and all the London-clay star-fishes; together with six plates of fossil Echinidæ. The extreme beauty and admirable preservation of the Echinidæ, are well known to every one who has ever examined a collection of oolitic or chalk fossils, and the importance of a careful investigation of their forms, and an accurate determination of the species, subject in several cases to much variation in size and form, cannot be too highly estimated. The fact that some even of the most ordinary occurrence have been described under seven or eight different names, is in itself sufficient to show the value of such a general review of the group.

Professor Owen has given a brief but very important description of some reptile remains, from the Greensand of New Jersey, discovered by Professor Henry Rogers. They consist of crocodiles of two species, belonging to the same genus, as existing crocodiles or alligators, and which Professor Owen has named *Crocodilus basifissus*, and *C. basitruncatus*: of remains of a mosasauroid reptile, allied very closely to the Leiodon, for which Professor Owen has proposed the name of *Macrosaurus*; of true mosasaurus remains of the species, *M. Maximiliani*: and of teleosauroid remains, referred to a new genus, *Hyposaurus Rogersii*.* Although drawn up under most disadvantageous circumstances, resulting from the unfortunate loss of his original MSS. containing the detailed observations, a loss which every palæontologist must most deeply regret, this brief communication forms a very important addition to our knowledge of reptile life, during the earlier periods of the cretaceous epoch.

The fossil sharks of the United States, have been monographed with good figures, by Dr. Gibbes of Columbia, South Carolina.

Passing to the tertiary rocks, Dr. Carpenter, whose researches on the microscopic structure of shells are well known, has applied the same method of investigation to the examination of the intimate structure of the nummulina, orbitolites, and orbitoides, and has given a detailed and careful description of his results, accompanied by good figures.† His

* Quar. Jour. Geol. Soc. London, 1849, page 382.

† Quar. Journ. Geol. Soc. London, 1850, page 21.

observations entirely support the view that nummulina belongs to the foraminifera, as also the orbitoides of D'Orbigny; while he doubtfully refers the orbitolites to the *Bryozoa.* Whether this conclusion may be finally established or not, Dr. Carpenters' researches have laid before us some of the most beautiful structures as yet known, and we hope that with the experience he has already acquired in the use of the miscroscope, he may be induced to pursue such enquiries, and bring the same accuracy of observation to bear on the minute structures of other organic forms.

The Palæontographical Society have, during the past year, issued a most valuable monograph of the chelonian reptiles of the London clay, drawn up by Professors Owen and Bell, illustrated by thirty-eight very excellent plates and some wood-cuts. In this monograph we have detailed descriptions of eleven species of Chelonia, eight of Trionyx, two of Platemys, and six of Emys, in all of twenty-seven species from this one formation alone, the eocene tertiary of England.

This publication, taken in connexion with the able paper by Professor Owen, in which he discusses generally, the homologies and development of the carapace and plastron of the Chelonia,* leaves little to be desired with regard to this family of fossils, and renders perfect up to the present time, our knowledge of the several species found in our eocene deposits.

From the same Society we have also the first part of a monograph on the mollusca belonging to the same geological formation, including the *cephalopoda,* drawn up by M. F. Edwards. Thirteen species are described and figured; a very large number of synonymes being reduced to this number. These two well illustrated monographs furnish an amount of information regarding the fossils of our eocene deposits, which could not have been obtained previously, except by minute, tedious, and detailed research.

Reuss and Von Meyer have jointly contributed a valuable paper on the tertiary fresh water formations of Northern Bohemia*—formations remarkable for the number of beautiful land-shells contained in them, all apparently new.

Mr. Carrick Moore† has described some tertiaries in the Island of Saint Domingo; noticing four species of foraminifera, and seventy-

* Von Meyer, Palæontographica, 1849.

† Phil. Transac. London, 1849, page 151.

seven of mollusca which occur in them, besides fishes' teeth, (*Carcharodon megalodon,* Agas) corals, and one echinoderm, (*Scutella.*) Of the shells, thirteen are identical with existing species, and two are doubtful—fifty-nine are considered new, and descriptions given, with figures of some. From a review of the whole evidence, Mr. Moore considers these deposits to be of miocene age. A very remarkable and interesting circumstance connected with these deposits, is the striking resemblance which many of the shells have to recent species which inhabit the seas of China, Australia, and the western coast of America. One is identical with an Indian Ocean species, (*Venus puerpera* Linn,) and another (*Phos Veraguensis*) is found in the bay of Veragua, on the eastern side of the continent. Now, the tertiary beds which flank the Cordilleras, have not one single species in common on the two sides.—(D'Orbigny.) In the North American miocene beds, all the species, which occur also recent, are without exception Atlantic species, while in this case we find two species, now found recent only in the Indian and Pacific Ocean, occurring in a fossil state in beds connected with the Atlantic. Mr. Moore accounts for this by pointing out the narrowness and lowness of the land in the Isthmus of Panama, which no where attains an elevation of more than 1000 feet; and thinking that a connexion between the two oceans might have existed here in the equatorial regions, long after a separation had taken place more northerly and southerly, where the range of the Andes presents points of 4,500 feet elevation and more.

A somewhat analogous case of the occurrence of fossil remains of peculiar character, pointing to former connexion of districts of the earth's surface, now, and long separated, is pointed out by M. Gervais, who announces the very interesting discovery of the remains of elephants and mastodons in Algieria. Of the elephant, the remains found are referable to the species *primigenius,* of which Sicily has hitherto been the most southerly limit; of the mastodon the remains are more nearly allied to the *M. brevirostre,* which is pliocene, than to M. angustidens, which is of miocene age. Many of the terrestrial and fluviatile remains of the south of Europe and north of Africa agree—the existing fauna and flora agree—and belong to the same centre of creation; and the finding in the fossil state, in caves in the south of France, of animals which still exist on the coast of Barbary, mixed with others which

† Quar. Jour. Geol. Soc. London, 1850, page 39.

belong to the basin of the Rhone, is another important fact, which, coupled with these recent discoveries of mastodon and elephant remains, is of peculiar value as bearing on the question of the former connexion of the south of Europe and the north of Africa during the recent portion of the tertiary epoch.*

The same author has carefully investigated the mammalia of the genera Palæotherium and Lophiodon, met with in the south of France. He has found that among these are several found in the eocene-beds of the Paris basin, as P. *magnum, crassum, medium, curtum, minus. Anoplotherium commune*—the other species being principally new, and therefore of no value as evidence of age. From these facts, he concludes that the beds in the south of France are of the eocene period, and not miocene, as hitherto supposed. He thinks that the genera Paloplotherium, (Owen,) and Plagiolophus, (Pomel,) have no sufficient grounds, and are in reality Palæotheria. With regard to Lophiodon, after pointing out some distinctions in their character, which he thinks sufficient to warrant a new arrangement of them, he asserts, that the Lophiodons, and the animals found with them, constitute a distinct population, their remains being found in very varied mineral beds, clays, sands, limestones, &c.; but though difficult to decide exactly, he is inclined to think them all eocene.†

M. De Christol has considered the general classification of the Pachyderms, and divides them into two great groups, according as they have molar teeth, with or without cement. The acementodont pachyderms do not differ from the others in this respect only; but this is considered the most essential distinctive point. The differences are fully pointed out, and the author concludes from the examination of the two parallel series, into which he divides the whole order, that in all the families of the order of pachydermata, the acementodont group is more ancient than the cementodont.‡

M. Christol§ has also announced the finding, in the marine sands of Montpelier, (in which the metaxytherium cuvierii occurs,) of several bones of the limbs of an ape, (*Pithecus maritimus*—Christol,)

* Comtes Rendus, tom xxviii., 12th March, 1849, page 362.

† Com. Rendus, tom xxix., Oct. 8, 1849, page 381,

‡ Comtes Rendus, tom xxix., page 363.

§ Bull. Soc. Geol. France, tom vi. page 169.

also a felis with cutting, and strong canine teeth, to which he has given the specific name of *Felis maritimus,* and some other interesting remains.

Messrs. Dubreuil and Gervais have discovered in the salt-water molasse of Castries, in the department of Herault, the nearly entire coronoid bone of a dolphin, nearly as large as the *delphinus rissoanus or griseus* of the Mediterranean, but differing entirely from them, from another dolphin found in the blue molasse of Vendargues, from the squalodon of Bourdeaux and of Malta, and from all known delphini, by its teeth, which are very broad as compared with their length, from which circumstances the authors have given it the name of *Delphinus brevidens.* In the same rock, they have also found the *Myliobates micropleurus* (Agas.)*

Giebel† has given a list of the animals, whose remains are found in the cave called Sandwicker-höhle, and the occurrence of a bird's egg in the tertiary limestone of Weissenau, near Mayence, is stated by Becker.‡

Professor Nillsson of Lund's valuable researches, in the history of the recent and extinct bovine animals of Scandinavia, have been given to the English reader in the Annals of Natural History,§ and will be found particularly interesting to the Irish observer, from the comparative abundance in this country of the remains of some of the species described.

The Rev. W. Smith has described ‖ the occurrence of an earth very rich in diatomaceæ, on the banks of Lough Mourne, near Carrickfergus, in which he has noticed no less than fifty-five species in sixteen genera. He also briefly notices the difference in the character of the species observed in this earth, and those in another deposit from the shores of Lough Reavy, in the adjoining County of Down; the species in one indicating level pastures, surrounding the lake, while in the other they are of a sub-alpine character, and he points out the value of such enquiries to the geologist, who may, from these minute and microscopic remains, be able to argue as to the

* Comtes Rendus, January, 1849, page 135.

† Neues Jahrbuch. Leon. ünd Bronn, 1 Sept. 1849, page 56.

‡ Do. Do. Do. page 69.

§ Ann. Nat. His. Oct. Nov. Dec. 1849.

‖ Ann. Nat. His. Feb. 1850, page 121.

physical conditions of the surface in the vicinity of which the deposits have been formed.

Though not distinctly bearing on Palæontology, the researches of Mr. Edmonds, junr., on the shells found beneath the surface, and in the sand hills near Penzance, are still not without their interest to the geologist, as establishing the fact of changes in the distribution of species, occurring in such very recent periods. He finds that out of twenty-seven species, the remains of which he has discovered in abundance, there are no less than five which do not exist at present within ten or twelve miles of the locality; nearly one-fifth of the entire number, which, so far as that immediate place is concerned, may be considered extinct at present. The fact of even this local disappearance of species is important.

Again, as bearing on the laws of the present distribution of shells, a brief paper* by Captain Thomas Hutton, on some land and fresh-water shells from Affghanistan, offers some points of great interest. Among twenty-four, which he found, four are stated to be British or north European species, viz.—*Succinea putris*,
„ *Pfeifferi*,
Limnea peregra,
„ *truncatula*,
while some others are so closely allied, that he is inclined to think them only varieties of European species. If the identity of those mentioned be fully established, the fact is a remarkable one, for it must be remembered, that these are terrestrial and fresh-water molluscs, not marine.

We have to express regret, that the Ray Society has not, during the past year, issued any work to its subscribers.

The application of mineralogical studies to the more accurate description and examination of mineral aggregates, has engaged the attention of several geologists and chemists. To M. Delesse,† we are indebted for a memoir on a porphyritic rock with a base of felspar, which occurs in the (transition ?) group of Chagey, in the department of Haute Saone. This rock is a green porphyry, the base of which

* Jour. Asiatic Society, Bengal, July, 1849, page 649.
† Bull. de la Soc. Geol. de France, tom vi. page 383.

is a felspar, occurring in crystals, generally green, but of which the colour is often nearly as marked as that of the paste, so that the porphyritic structure of the rock is not always well characterized. On exposure, the first effect produced, is to give a red colour to the felspar, after which it kaolinizes. Its density (mean) is 2.736, and its hardness less than 6. The crystals appear to be macles, but are not well defined, the felspar belonging to the last crystalline system. Its composition was found to be—

Silica,..................	59.95	61.71
Alumina,...............	24.13	25.44
Peroxyde of Iron,......	1.05	
Protox of Manganese,	traces	traces
Lime,..................	5.65	4.79
Magnesia,..............	0.74	2.98
Soda,..................	5.39	2.74
Potash,................	0.81	
Water,.................	2.28	2.34
	100	

Taking away the water of this felspar, we find that its composition is nearly that of *oligoclase;* but if on the contrary, we admit that water plays the part of a base in this felspar, and if it be further supposed that three atoms of water replace one of magnesia, according to M. Scheerer's ideas, the formula of this mineral would then be very nearly that of *Andesite.*

The density of the mass of the rock was found by M. Delesse to be higher than that of the contained felspar, being 2.759. The magnetic force is also high, being equal to 473 : that of steel being represented by 100.000. The loss, by heating, of the mass, was more than that of the constituent felspar. An analysis of a portion of the paste, which appeared poorest in felspar, gave the results in the second column. These analyses give, then, extreme limits between which the chemical composition of the porphyry is confined, and they show that the extent of these limits is very slight. These results are analogous to those obtained by the same author for the porphyry of Belfahy ; and he considers them common to all porphyries, having as a base, a felspar of the sixth system, associated with a certain quantity of Silicate of Iron and Magnesia. He considers this porphyry as a metamorphic rock, resulting from the action on

the transition schists of a dyke of porphyry, similar in composition to that of Ternuay, which occurs near Chagey.

To the general proposition of M. Delesse, that the water which he finds in these felspars is water of combination, M. Deville objects, that the specimens examined were not transparent, and had not that purity which was essential before admitting them as a type of a new species of felspar, although he admits that the water exists. M. Durocher also objects, referring to results which he had previously obtained, in which he found that silicates, supposed anhydrous, even hyaline quartz, contain generally a 500th, or even a 50th part of water, which remains at a temperature of 100°. Felspars also contain more water in proportion as they are less transparent, are opaline or milky, or are less distinctly cleavable. He thinks that a case of diaphanous and colourless felspar, with brilliant faces, and constant angles in the crystals, is the only one which would justify a specimen being taken as the type of a new species, and supposes that in most cases the water which the felspars do contain, may be accounted for by a mixture of foreign substances, especially of hydrated silicates, analogous to zeolites. M. Durocher also thinks, that the perfect type of chemical purity cannot be met with in pyrogenous rocks, since their elements have been separated from a general magma, and have crystallized in contact one with the other. The pure minerals are met with in druses and veins; here we frequently find the summit of the crystal quite different from the base, and crystals showly forming from an aqueous solution, acquire a greater purity, than those which crystallize from a state of igneous fusion. In the latter case the reciprocal, or mutual interlacing of the crystals, show that they have crystallized nearly at the same time; and consequently the isolation of the particles of different natures could not, as M. Durocher supposes, be perfect. Experiments also proved to him, that several silicates, felspar among the number, when exposed for a long time to moist air, take up or absorb a small quantity of water, which is not parted with at 100°.

These objections have elicited from M. Delesse a general discussion of the question of the presence of water of combination in felspathic rocks. The fact of water occurring in such rocks is unquestionable; but the question is, is it in the state of combination or not? Is it cotemporary with the formation of the rock, or pos-

terior to it? If posterior, it may be either—1st, hygrometric, or 2ndly, derived from a pseudo-morphosis, or a decomposition.

The large amount, from 1 to 3.15 per cent. proves that it is not hygrometric water; nor is it water absorbed in the quarry; which would be given off, when dried. If due to a decomposition, then the loss by heat would be greater or less in proportion to the amount of the drying; but this was not the case, as the loss of the felspars was the same, with very slight variation, both before and after desiccation for many hours, in a sand-bath below 100. Felspars also, in the first stage of decomposition, or rubefaction, sometimes contain less water, but never more; when kaolinized they contain much more, but then they lose their crystalline form, and break up. The hardness and cleavage of the felspar remaining constant, show also that there has been so pseudomorphosis. Admitting, therefore, that the water is not posterior to, but cotemporary with the formation of the rock, two hypotheses still remain.

1. Is this water derived from an intimate mixture of some hydrated mineral? or

2. Is it water of combination essentially belonging to the mineral in which it is found?

The first hypothesis has been generally admitted up to the present. The water in basalts and traps has thus been generally attributed to a certain quantity of zeolite. In some cases this has been considered to be Thompsonite, in others a mixture of nepheline and mesotype, in others, different again; and thus, although basalts are remarkably constant in their aspect, the zeolite mixed with them would appear very variable. M. Delesse had already proved that the melaphyres contain not less water than the basalts;* but the best characterized melaphyres contain no zeolites at all; and where the latter do occur, they are found only in druses and cavities. The minerals, however, which occur in these druses, are quite different from those found in the paste, and their occurrence in one place by no means proves their occurrence in the other; and in reality, none of the minerals found in these druses occur in the paste, (such as quartz, chlorite, epidote, carbonate of lime, zeolites.) Again, if zeolites form a portion of the paste, when it was subjected to the action of acid, a jelly of silica would

* Annales des Mines, tom xii., 4e serie.

result, and readily, owing to the minute state of division of the silica, but this is not the case. Basalts, thus attacked, do occasionally give a jelly, but this may be from a mixture of peridote. The mere fact of a rock being attackable by acid, without leaving a jelly of silica, does not at all prove the existence of zeolites. Supposing, too, for a moment, that the water is derived from such a mixture of zeolites, and that these contain even so much as ten per cent., (as natrolite,) since the labrador-felspar of the melaphyres often has two per cent., occasionally four to five per cent. of water, there must be a mixture of one-fifth to two-fifths of zeolite. Nor is the felspar the only mineral which contains water—but the augite also. In the porphyry of Ternuay, an asparagus-green augite has 2.26 of water; or granting this hypothesis, is in other words mixed with one-fifth of zeolite, and yet these felspars and augites, have remarkably well defined cleavages, much too distinct and neat to be possible, if there were twenty to one hundred per cent. of foreign matter mixed with them. They are translucent, occasionally transparent, and have a uniform tint. Besides the felspars in the syenite of Ballon d'Alsace have 1.30 per cent. of water, and that in the granite rocks of the Vosges, and Brittany, and Normandy, nearly as much. Now, the presence of water in these felspars can be even less attributed to a mixture of zeolite in these granitoid rocks, than in the others.

Therefore, M. Delesse concludes, from the mode of occurrence of zeolites in rocks—from the absence of any siliceous jelly, when subjected to acid—and from the perfection of the crystals containing water, that it is impossible to admit that this water is derived from an admixture of any foreign substance; and that we are therefore compelled to admit that the water of felspathic rocks is water of combination peculiar to each of the minerals in which it is found.

Taking the whole series of unstratified rocks, the author finds that nearly all contain water of combination in different quantities. In granites and syenites it occurs, but in very small quantity, not more than one per cent. In porphyries, basalts, melaphyres, euphotides, &c., we have several per cent. Or taking the ordinary minerals which enter into their combination, we have for mica as much as several hundredths sometimes, but very variable. Amphibole and hypersthene contain a very small amount of water—sometimes more. Diallage sometimes three per cent. or more; augite 2.75—(the varie-

ties containing most water generally have a clear green colour.)—the felspars vary much—orthose seldom has any: never more than a few thousandth parts; while felspar, of the sixth system—saussurite, labrador, andesite, oligoclase, even albite and pericline have several per cent., the amount varying inversely with the amount of silica. The author had previously pointed out the peculiar characters of these felspars. They have a fatty lustre, and waxy fracture; cleavage is less distinct, and their density is greater than when there is no water; and they are, further, much less resistant to acids.

These memoirs of M. Delesse, on the rocks of the Vosges district, although we must express a doubt that his conclusions have been drawn from too few and too individual cases fully to justify him in drawing such general conclusions as he has from them, are extremely important as giving the results of careful analyses, not only of the mass of the rocks, but also of the constituent minerals.

The same author has undertaken, and largely carried, out a perfectly novel kind of research into the magnetic force,* (le pouvoir magnetique) of minerals and of rocks; and these researches he has extended considerably during the year. He has examined the oxydes of iron, and finds that the force of oxydulous iron ($\dot{Fe}\ \dddot{Fe}$) varies from 64.121 to 15.750, being greater in proportion as the crystallization is more perfect. Of titaniferous iron, $\dot{Fe}$ ($\dddot{Fe}$, $\dddot{Ti}$) within even greater limits depending partly on the amount of titanium, as from 50.000 to 10.000. In chromate of iron it is much less, not being more than 136. Thus, the magnetic force in these oxydes is (all other things being equal) in proportion to the amount of the sesquioxyde of iron, it has its extreme limit in oxydulous iron, and diminishes through titaniferous iron, franklinite, chromate of iron, to spinelle and pleonaste.

Again, the same author states that the protoxyde of manganese has a force equal to 24

The red oxyde,	43
Peroxyde,	56

So that the force increases with the amount of oxygen—a paradoxical result. All the sulphurets, antimoniurets, and arseniurets, (excepting magnetic pyrites,) have a value less than 100—as also the

* Comtes Rendus, tom xxviii., page 227. Annales de Chimie, Jan. 1849, page 148.

phosphates and arseniates—in quartz it is little or none: felspar and mica also very slight. The author concludes from these researches, that as the magnet is known to have a certain influence on all bodies, as Faraday and Plücker have shown, so, that all bodies have a certain magnetic force, which, varies most materially, and in some degree with their crystalline state.

Applying the same method of research to the rocks,* the author gives the results of his examination of twenty-nine varieties of volcanic rocks, lavas, &c., of thirty-six varieties of basalts, porphyries, melaphyres, serpentines, chloritic rocks, &c.

The basaltic rocks—even those containing very little oxydulous iron—have a force two or three times greater than the mean force of modern lavas. The magnetic force of basalts ranges between 1,500 and 3,000; that of lavas between 350 and 1,500, but more generally between 600 and 900. Of serpentines the magnetic force is very variable. The amphibolic rocks have a very low force, even below 100, sometimes scarcely sensible—stratified rocks also, generally speaking, have a low force. This force does not depend on the presence or absence of oxydulous iron, but is a real physical quality, which all rocks possess in a greater or less degree; all varieties of the same rocks, no matter whence derived, agreeing very well in the magnetic force which they exhibit. M. Delesse thinks, that from such results, knowing the geological structure and constitution of a district, it would be possible to determine by calculation the deviation of the needle relatively to the meridian of that place.

As might be expected, when we remember the excitement caused by the first announcement of the discovery of considerable quantities of gold in California, and the sustained interest which the arrivals from that country have maintained, there have been, during the year, several analyses published of this gold; and the general question of its distribution and character has been discussed. M. Dufrenoy has given the results of a comparative examination of the auriferous sands of California, of New Grenada, and of the Ural Mountains. The little plates of gold from California are much larger than those from the Ural or from Brazil; and they are also distinguished by their reddish colour.

* Annales des Mines, tom xv., 4th series, page 497.

The gold sometimes adheres to white milky quartz, much rounded, and evidently having been subject to great friction; there are also schistose fragments, both of which facts shew that the original source of the gold is in granitoid schists. The general colour of the sands is black, from magnetic iron; there are besides titaniferous iron, oxyde of manganese, crystals of white zircon, (both ends perfect,) also quartz, (hyaline and smoky,) and some fragments of blue corundum. The crystalline state of the titaniferous iron and of the zircon, (which, though usually a rare mineral, is here abundant,) show that they have not travelled far.

The New Granada sands are more grey than black—they contain less iron—more zircon—the quartz is but little rolled; sometimes both extremities remain: the sand altogether is less rolled than that of California. In the Ural sands there occurs cymophane. Estimating the proportion of each of these by actual separation, there resulted for the sands from,

	California.		New Granada.	Ural.
Magnetic iron,...............	59.82		84.35	23
Titaniferous iron, Oligiste iron, and traces of Oxyde of Manganese,	16.32		15.0	50
Zircon,........................	9.20		20.00	3
Quartz Hyaline, ...	13.70		25.0	14
Corundum, ...	0.67		7.0	Cymophane 10
Gold, ...	0.29	Various rocks,	4.65	

Though a rough approximation, this is sufficiently near. The sands of the Rhine gave very similar results with a slight variation. The author remarks on the absence of spinelle in the auriferous sands which he has found in stanniferous sands from several places; and asks, can we conclude that this mineral belongs to crystalline rocks of an earlier date than those containing gold?

M. Dufrenoy then enters on some calculations to show that the Californian gold region, even allowing the truth of the high estimates which have been made from first washings, is not much richer than the Ural, and that the discovery of gold there will not, therefore, in all probability, produce any important revolution in mining industry.

M. Rivol* has analysed several specimens of gold from California, and the mean of all his results gave—

Gold,	90.87
Silver.	8.60
Iron,	.10

Mr. Henry also, in March, 1849, gave analyses of Californian gold as below:—

Gold,	90.01	....	86.57
Silver,	9.01	....	12.53
Copper,	0.86	with traces of iron,	0.29
Iron,		....	0.54
	99.88		99.73

The specific gravity was 15.96.†

M. Teschemacher‡ also gives an analysis of Californian gold, of which the result was—

Gold, ...	90.68
Silver, ...	1.00
Oxyde of iron,	6.80
Copper, ...	0.66

The specific gravity was 16.33. If the iron, &c. be deducted, we have an alloy of gold 92., silver 7.

The question whether the gold and silver are combined in the atomic proportion has been entered upon by M. A. Levol,§ who gives numerous analyses which he had made during twenty years, without having this object in view; and from the discussion of his results, he thinks it established, that, generally speaking, gold and silver are found united in such proportions that they can be reduced to atomic formulæ, although at the same time they present themselves also in an almost endless variety of proportions.

The occurrence of gold, though in very small quantity, has also been proved,|| in the copper mines of Chessy, (dept. de Rhone.) The ores here have, besides sulphur, iron, silica, and arsenic, some eight per cent. of zinc, and five per cent. of copper, and about $\frac{1}{10,000}$ of gold, which it is thought may be extracted profitably by the adoption of a peculiar process.

* Annales des Mines, tom xvi. page 127.

† Phil. Mag. March, 1849, page 205.

‡ Jour. Chemical Society, London, October, 1849, page 193.

§ Annales de Chemie, tom xxvii. page 311,

|| MM. Allain et Bartenback, Comtes Rendus, tom xxix. page 153.

M. Daubree* has made some very interesting experiments on the artificial productions of minerals, adopting the same mode of research, as had already yielded such important results to Sir James Hall, Berthier, Mitscherlich, &c. He had been led to some considerations of this kind, by the study of veins of tin and titanium, and he had been convinced that fluoric acid played a very important part in the production of these veins. Besides tin, these deposits frequently contain fluo-silicates, such as mica, lepidolite, topaz; boro-silicates, as tourmaline and axinite; fluophosphates, as apatite; and the principal circumstances of the structure and composition of stanniferous veins, would be explained by supposing that vapours, containing fluoride of silica, of boron, and of phosphorus, came at a high temperature from below. To imitate this process was, therefore, M. Daubree's object; and he therefore caused two currents to pass through a porcelain tube, heated to a white heat; one of vapour of perchloride of tin, the other of vapour of water. Mutual decomposition readily took place, and the interior of the tube, towards the extremity, where the two currents entered, was covered with well formed, crystallized, and very brilliant crystals of oxyde of tin; the central and strongly heated portion had no deposit, and the other end only an amorphous deposit of oxyde of tin, which was also found abundantly in the tube of glass, united to that of porcelain. The crystals were colourless and transparent, except a few, which were brown, and they had all the adamantine lustre of natural crystals; and they differed only from the natural oxyde of tin in being colourless, having no oxyde of iron associated. In form they were right rhomboidal crystals, very flattened; while the natural crystals of oxyde of tin are derived from a right octahedron, with a square base. The oxyde of tin appears, therefore, a new case of dimorphism. This artificial oxyde of tin is also isomorphous with oxyde of titanium or Brookite; but native oxyde of tin is isomorphous with Rutile; and thus Rutile, Brookite, and Anatase, having been shown by Henry Rose, to be only titanic acid with oxyde of iron, it follows, from these experiments, that the two forms of oxyde of tin correspond with the two forms of oxyde of titanium. And this correspondence furnishes a new example of the close geometric relation

* Annales des Mines, tom xvi. page 129.

which generally unites the primitive forms of a dimorphous body, as in the case of carbonate of lime, of magnesia, &c.

The density of the natural or octahedral oxyde of tin is 6.80 to 6.96. The density of the artificial or Rhombic tin is 6.72. Similarly with Rutile and Brookite, the former has a specific gravity of 4.291; the latter of 4.128 to 4.167; so that the form of the square prism co-exists with some molecular condition, conferring a higher density than the form of the right rhombic prism.

Similar results were obtained by operating with chloride of titanium—very minute crystals of titanic acid being formed in the tube; these were two minute to measure, but appeared to be of the form of Brookite, that is of the same form as the artificial oxyde of tin. Similar results were also obtained from fluo-silicic and chloro-silicic acids, the deposits in both cases being silica, with a glassy structure and fracture: in the case of the fluo-silicic acid, it was fibrous. The crystals adhered very strongly indeed to the sides of the tube, as they do in nature to the rocks.

Having established these experimental results, the author proceeds to apply them to the explanation of his views in nature, and describing the structure and composition of veins in various countries, shows that there is a mutual interpenetration of the crystals of rutile, of fer-oligiste, and of quartz, which proves that they have been formed if not at the same moment, at least under the same conditions. This interpenetration is well known to mineralogists.

Knowing, then, that the fer-oligiste of volcanic countries is due to the decomposition of chloride of iron, by the vapour of water, a similar origin may be, he thinks, attributed to the fer-oligiste of the titaniferous veins; and that all these minerals result from the decomposition, by the vapour of water, of their respective chlorides or fluorides. The presence of fluoric combinations is supposed to confirm the supposition, such as fluor-spar, fluo-silicates, (mica) fluo-phosphates, (apatite) boro-silicates, (axinite, tourmaline.) We have beside, hydrated silicates, such as chlorite, and occasionally zeolites, tending to prove that water has had an important part to play in the filling of these titaniferous veins.

In a few exceptional cases, the fluoride of titanium has been, as it were, withdrawn from this decomposition, as in the Warwickite of New York, and the Eremite (of Dana) in Connecticut.

The author further presses the idea, that if this be the origin of such deposits, fluoric acid must have been more widely diffused, and have played a much more important part than is generally supposed. He thinks also that such experiments may tend to throw much light on the metamorphism of rocks.

In connexion with these researches of M. Daubree, we may mention an interesting paper on Arkansite, by Messrs. Damour and Descloizean. This mineral, it is known, presents an iron grey colour with a metallic lustre, similar to that of oxydulous iron. Its density is 4.030 in crystals, 4.083 in fragments. The crystals are generally dodecahedrons, with isosceles triangles, but the measurements show that they belong really to a right rhombic prism, modified.

On a careful comparison of their form, and its usual modifications, (the details of which are given) the authors were led to see that it was identical with the form of Brookite. Analysis also showed the close relation in composition. On the other hand, Brookite is well known to be totally different in external characters. It is found in very flat crystals, often small, transparent, of a red brown colour, with a vitreous fracture, and yielding a yellowish white powder, instead of cinder grey, as in Arkansite.

Now if a crystal of Brookite be placed for a few moments in the inner flame of a blow-pipe, it loses its transparency, and assumes the aspect of a little plate of iron. After this operation it has also a vitreous fracture and a metallic lustre, and its powder also becomes grey, exactly like the lustre and powder of Arkansite. The same is the result of heating it on charcoal; but it does not change its aspect when heated in a tube. These facts would all tend to prove that the crystals of Arkansite belong primarily to the species known as Brookite, but that they have been in some way subjected to a high temperature, with the disengagement of hydrogen, or bituminous vapour. Under this influence they have undergone a slight reduction, by losing a part of their oxygen, and have assumed a different external character without altering their form.

Rutile suffers the same change exactly, increasing in density. Now M. Ebelmen had already shown that titanic acid could be changed into sesqui-oxyde of titanium, by exposing it to the action

of a current of hydrogen, at a high temperature.* The author therefore concludes that Arkansite is a compound of sesqui-oxyde of titanium and of titanic acid, arising from a chemical alteration of crystals, originally belonging to the species known as Brookite.

M. Whitney, in America, had also examined the Arkansite, and found its composition as above, thus upsetting the notion of Shepard, that it was a niobate; and also stated, that it had the crystalline form and density of Brookite.†

Professor Miller, of Cambridge, also examined the crystallographic identity of the two;‡ and Rammelsberg made the same statement, and gave the details of the measurement confirming it; and he also published careful analyses of the mineral, from which he came to the conclusion, that Arkansite had the crystalline form of Brookite, and the specific gravity of Anatase; it was therefore only a variety of Brookite.§

Bearing on the same subject, is the discovery of Woèhler, that the cubic crystals found in the slags of iron furnaces, and hitherto supposed to be pure titanium, really contain cyanide and nitruret of titanium, having eighteen per cent. of nitrogen, and four per cent. of Carbon.‖

M. Damour has analysed a new specimen of the rare mineral Periclase, which was first discovered and described by Professor Scacchi, of Naples. The previous analyses had given only an anhydrous magnesia and oxyde of iron, and had excited considerable doubt as to their accuracy, it being difficult to conceive how such an oxyde of magnesium, with marked alkaline properties, should exist in nature in a state of purity, in distinct crystals, and yet not decomposed. The discovery of a considerable quantity of this mineral in a block, at Monte Somma, gave M. Damour an opportunity of examining it carefully. It is found disseminated, both in small irregular grains, and in cubes and well marked octahedrons, in a mass of white

* Annales de Chimie, tom xv. 3me serie, p. 385.

† Silliman's Journal, No. 21, vol. vi. page 433.

‡ Phil. Mag. July, 1849, page 75.

§ Ueber die identitat, &c., Poggendorff's Annalen, vol. lxxvii. page 586; see also Pogg. Annalen, vol. lxxii. pages 123, 302, and vol. lxxviii. page 143 for other papers on the same subject.

‖ Comtes Rendus, tom xxix. page 505, 5 Nov. 1849.

lamellar carbonate of lime. The results of two analyses are given, (the processes employed being detailed at full,) and the mean of these yield—

Magnesia, ...	93.62
Protox of Iron,......	05.99
	99.61

The specific gravity is 3.674. Is then the protoxide of iron only an accidental colouring matter, or is it essential to the crystallization of the Periclase? If the latter, the formula representing Periclase, will be—

$$24\ \dot{Mg} + \dot{Fe} \quad \text{or}$$
$$24\ (Mg + Fe) + 25\ O$$

It appears most probable that in Periclase there is native magnesia crystallized, containing a small portion of isomorphic protoxide of iron, just as in Corundum we have alumina, in quartz silica. The gangue of the periclase is a mixture of carbonates of lime and magnesia, in the proportion of four of the former, and one of the latter.*

The same chemist has re-analysed the sapphirine, and found results quite confirming those of Stromeyer who first examined this mineral. The specific gravity was a little higher, being 3.473.†

We have had two valuable communications brought before this Society, during the past session, on the analysis of minerals. Mr. William Mallet has shown by a very careful, and well described analysis of Killinite, that the specimen on which he experimented, and which appeared a good typical specimen of the Killinite, differed considerably from those previously analysed, and presented the interesting fact of containing lithia to a sensible amount, and establishing its distinctness from Spodumene. For the details of this communication, I must refer you to the journal of the Society.‡

Another was from Mr. Sullivan, on the composition of some mica, obtained from the altered rocks in junction with the granite, at Glenmalur, in the County of Wicklow.§

* Bull. de la Soc. Geol. France, 5 March, 1849.
† Bull. Soc. Geol. France, 1849, page 315.
‡ Jour. Geol. Soc. Dublin, vol. iv. page 142.
§ Jour. Geol. Soc. Dublin, vol. iv. page 155.

For the knowledge of the processes adopted in the analysis, and the detailed numerical results, the accurate description of Mr. Sullivan must be consulted; but I may notice here the interesting fact established by this examination, that the mica, which was biaxial, contained 2.506 per cent. of soda, with only traces of the oxides of Chrome, with Fluoric, Boracic, and Phosphoric acids, (the latter possibly accidental.) Mr. Sullivan discusses the mode of occurrence of these, and has promised the results of the analyses of a more extended series of micas, on which he is engaged. The total absence of lithia in that examined is also deserving of notice.

Professor Silliman has shown by analysis that the Indianite of Bournon, the matrix of the Asiatic Corundum, is chemically the same as Anorthite.*

August Stromeyer† has shown the occurrence of oxide of nickel in Serpentine and talc :—

In the bright green serpentine, (precious) of Röraas, there was	0.45 per cent.
Sundal.........	0.304
In the dirty yellow common serpentine of Röraas,............	0.32
" " Saxony,..............	0.22
In the bright green talc of Röraas,..............................	0.40
Sell,.................................	0.43
Throndjem,.......................	0.23

Dr. Leeson has continued his researches on crystallography in a paper on Isormophism, and on a general simple law governing all crystalline forms, in which some new views are announced.‡

The recent statements by Malaguti, Durocher, and Sarzeaud,§ with regard to the presence of lead, copper, and silver in sea water, and of silver in organized bodies, must naturally excite attention. The water was from the sea at St. Malo, and the fuci examined from the same place; the ashes of these *(fucus serratus* and *ceramoides,)* contained $\frac{1}{100.000}$; the water only $\frac{1}{100.000.000}$ of silver; they state also that salt and all its artificial products contain silver. In the ashes of fuci they have found $\frac{18}{100.000}$ of lead, and a little copper; so that

* Silliman's Journal, Nov. 1849.

† Nyt. Magazine fur Naturvidenskaberne, Christiania, vol. vi. No. 1, 1849.

‡ Jour. Chem. Soc. of London, 1849.

§ Comtes Rendus, tom xxix. No. 26, page 780.

these metals also are concluded to exist in the medium in which these plants live.

The extreme caution requisite in such experiments, when the reagents used may possibly have been lying exposed in a laboratory used for general analysis, or have been subjected to other sources of impurity, is known to chemists; and an instance of it may be referred to in Mr. Arthur Phillips' analyses of the ashes of coal, (analyses undertaken with a view to test the truth of statements, made with regard to the occurrence of lead, and copper, in such ashes,) in which he found no traces of lead and copper, but on testing the distilled water of the laboratory found, that it darkened with sulphuretted hydrogen.*

Rammelsberg has issued a fourth supplement of his very valuable dictionary of the Chemistry of Mineralogy.† And Bischof has continued his very important contributions to the chemical and physical portion of geology, in which he discusses the history of Augite, of Diallage, Bronzite, and Hypersthene, of Augitic rock, of Olivine, and of Basalt.‡

During the year the Cavendish Society have issued two additional volumes, (two and three,) of Gmelin's Hand-book of Chemistry, a very carefully executed translation by Mr. Watts, who deserves much praise for the conscientious manner in which he has performed a task of no small labour, and has used his best efforts to bring up the information contained to the last moment.

The question of the origin and mode of formation of dolomites, has continued to engage the attention of several enquirers. Among others, Professor Favre of Geneva, has discussed the origin of the dolomites of the Tyrol,§ adopting as the basis of his hypothesis some experiments of M. Marignac. In these some carbonate of lime, and a solution of chloride of magnesium, were placed in a strong glass tube; the tube sealed hermetically, and subjected to a temperature of 200° cent. during six hours; the result was the formation of a dolomite, or a double carbonate of lime and magnesia, containing a larger proportion of magnesia than a true dolomite.

* Quar. Jour. Chemical Society, London, April, 1849, No. v. page 1.

† Handwörterbuch des, &c., Viertes supplem. Berlin, 1849.

‡ Bischof, Lehrbuch des Chem. ünd Physic. Geol. 11 band 8 heft.

§ Biblio. Univ. tom x. page 177; also Comtes Rendus, March, 1849, page 364.

Repeating the same process, but continuing the high temperature for only two hours, a limestone slightly magnesian was the result; showing that time was one circumstance important in the question. There would appear, therefore, to be requisite for the production of dolomite in this way—1st, lime; 2nd, sulphate of magnesia, and chloride of magnesium; 3rd, temperature of 200° cent.; and 4th, a pressure equal to 15 atmospheres, or from 450 to 600 feet of sea water.

M. A. Favre, adopting these results, points out the probable concurrence of all these circumstances in the case of the dolomites in the Tyrol. There are here, however, two kinds of dolomite, one compact, the other cavernous: the former, the author supposes to have been originally deposited; the other, to be the result of alteration—an alteration, which he thinks took place almost immediately at the time of their deposit; or, as it were, a nascent metamorphosis. He supposes, further, that the fact of the connexion between the occurrence of dolomites, and the eruptive porphyries is due, not so much to any subsequent change, but to the more abundant deposit or formation of magnesian limestone around these centres, from the reactions there occurring having produced the magnesian character, while ordinary limestone was being deposited in other parts. The saccharine and crystalline dolomites he views simply as the result of the fusion of a magnesian limestone, not of any sublimation of magnesia; while the sulphate of magnesia being decomposed by the carbonate of lime, and this reaction taking place when warm, the sulphate of lime resulting would be in the anhydrous state, and thus we have an explanation of the occurrence of anhydrite.

Mr. James Bryce, junr., has given the results of careful quantitative analyses of the altered dolomites of the Island of Bute, his description of which I had the pleasure of noticing in last year's address.*

These analyses, carefully executed by Dr. R. D. Thompson, fully bear out the unexpected and interesting facts stated by Mr. Bryce, that the igneous action in the cases referred to, has driven off the magnesia from the limestone; the portion altered by the dykes, containing a much smaller proportion of magnesia than that which is unaltered.†

* Jour. Geol. Soc. Dublin, vol. iv. page 103.

† Philos. Mag. August, 1849, page 81.

Relating to the application of geological principles to practical pursuits, there have been published, during the year, some few valuable contributions.

In a detailed communication* on the iron deposits of the departments of Aveyron, of Lot, &c., M. Coquand, enters on a minute description of the general mode of occurrence and character of the beds worked. The chief supply is derived from the jurassic group, consisting of *fer hydroxide compacte,* mixed with a considerable proportion of carbonate of lime, and *fer hydroxide oolitique,* (pisolitic iron.) The latter is the most abundant, and occurs not forming beds of any great or continuous extent of surface, but small well-marked islets, as it were, in which the richness of the mineral increases towards the centre, and gradually dies away towards the edges. These are quite free from phosphorus, sulphur, and arsenic, and yield iron of the best quality. They occur in compact masses in red clays; in rognons of a variable size, with rounded surfaces; in grains, cemented by a clayey paste; and in pisolitic grains, in the cracks of the secondary rocks. Besides these, there are deposits of iron hitherto called alluvial, (but which M. Coquand has shown to be tertiary,) some of which are remarkable, as being almost entirely beds of fossils, (as *Gryphœa cymbium,*) and as containing, derived from these organisms, two to three per cent. of phosphoric acid.

The author gives a very full account of the circumstances under which these deposits are found and worked; and enters at large upon the question of the age of the beds, in which they occur, showing that they rest unconformably upon the Eocene and Miocene, and that they form the upper portoin of the tertiaries of the south-west of France; and that this position, established stratigraphically, is confirmed by the fossils found in them.

From M. Durocher, we have obtained a detailed, minute, and valuable description of the metalliferous resources of Sweden, Norway, and Finland. His memoir, which, however, offers too much detail, to be analysed here, treats fully of the position, structure, character, and origin of the several veins or beds, and of the geological constitution of the rocks and country where they occur.†

* Bull. de la Soc, Geol. de France, March, 1849, tom vi. page 328.

† Annales des Mines, tom xv. 171.

M. Riviere, has given a description of the rocks, and contained metallic veins of the Rhenish provinces, in the district included between the neighbourhoods of Coblentz and Dusseldorf, on the right bank of the Rhine.*

The country is composed almost exclusively of grauwacke rocks, with here and there some tertiary deposits, and some igneous rocks. The metals occurring in the veins, are zinc, iron, lead, copper, silver, arsenic, nickel, &c.; principally iron, zinc, copper, and lead, chiefly in the state of sulphurets, and carbonates. It is stated that there are two principal systems of these veins, varying in composition, in direction, and probably in age. Now, the cleavage of the rocks is frequently not coincident with the bedding, and it is stated that the veins of the first system, composed of quartz, blende, galena, siderose, and traces of sulphuret of copper generally accompany the cleavage, and conform to it, while the others are more independent, and cut the bedding.

After a detailed account of the works undertaken in several of these mines, and of the extent, direction, and character of the several explorations, the author passes to some general considerations on metallic veins.

All veins of blende hitherto studied, are united by general relations. They are sensibly parallel, and have a mean direction of east north-east, and west south-west. At certain points they are nearly parallel to the cleavage of the greywacke, while at others they cut this at various angles, and have inclinations different from that of the greywacke. The cleavage in many cases is different in direction from the beds, so that when the veins appear to be sometimes parallel to the cleavage, it is because they have gone in the line of least resistance, or because the secondary fractures have been determined with greater facility in the direction of this cleavage.

The veins, then, being true veins, resulting from the cracks arising out of parallel dislocations, and their general directions corresponding to that of the enclosing rocks, these fissures are probably due to the same system of dislocation which has raised the greywacke. The ribboned character of the veins seems to shew that the filling in of them was subsequent, and at successive periods.

* Bull. de la Soc. Geol. de France, tom vi. page 171.

He thinks that veins having different directions may nevertheless be of competoraneous formation, and be of the same nature; and, while not altogether maintaining it in every case, he thinks the connexion between the age of veins and their composition, worthy of much more attention than it has hitherto received: believing, that there does exist some general relation between the direction of veins, (properly so called,) the nature of the materials of which they are composed, and the epoch of their formation.. He gives many instances in support of this view, and concludes by maintaining, that the older, and transition rocks, are the natural locality of metals, and that they occur, in the other rocks, principally as the result of a displacement or change of their nature, more or less complete.

Among the more curious applications of geological investigations, we would refer to the interesting enquiries of M. Boubeé, on the geological conditions of the cholera.* At the first invasion of this fearful disease in 1832, M. Boubeé had remarked that several places were severely attacked, and others escaped; and he had consequently undertaken many researches to ascertain whether this fact had any connexion with the geological nature of the soil, &c., being the more induced to consider this, by observing, that in many countries where endemic diseases prevailed, the limits of the area over which they spread, are frequently marked out by the limits of the geological formations, so that each geological formation constitutes, as it were, a natural locality for peculiar morbid affections, such that the medical constitution of a country depends in some way on its geological and topographical constitution. He points out the remarkable influence which the nature of the soil has on the absorbent powers, and dryness of the ground—on the coldness or heat—on the nature of the gases evolved; and further, the nature and amount of the mineral or organic matter taken up by the waters used for drinking, cooking, &c. And referring to the cases of goitre, confined chiefly, as we pointed out last year, to countries where the waters used contain magnesia—to the greater prevalence of pulmonary pthisis in countries where the soil is calcareous—he states that the cholera has shown itself with much greater virulence in those countries which are occupied by easily disintegrated rocks, and in general terms, by

* Bull. de la Soc. Geol. de France, tom. vi. page 540.

tertiary or alluvial deposits, extending itself with less intensity in countries where the older and harder rocks exist.

In confirmation of this idea, numerous localities are referred to by the author, and the circumstances appear fully to support his hypothesis.

In fact this case is only one out of many which might be quoted as evidencing the importance of an accurate knowledge of the structure of any district, before determining on the measures desirable to be adopted for its drainage, improvement, &c., if already inhabited; or in the case of new countries, before determining on the locality and site of town or settlements.

Bearing on some of the most important questions in physical geology, we have had two short, but valuable papers, from Mr. Hennessy,* during the year. In one, "on the changes of the earth's figure and climate, resulting from forces acting at its surface," the author has pointed out how inexplicable the observed phenomena of the earth's figure, and of the variation of gravity at its surface would be on the hypothesis of the earth's primitive solidity; and in the subsequent one, "on the variation of gravity at the earth's surface," he further shows, that this hypothesis entirely fails to explain the secular refrigeration of the earth's surface, its observed ellipticity, and the variation of gravity.

Mr. Hennessy has also communicated to the Royal Irish Academy, (Proceedings vol. iv. page 333,) a valuable paper, "on the influence of the earth's figure, on the distribution of land and water, at its surface;" and a second part of his researches in physical geology to the Royal Society of London.

All these papers forming portions of the same general researches, I regret that the details of the latter have not yet been published; and I must, therefore, omit any general notice of the author's results, as it would be obviously unfair to enter upon such an examination with the data now before us. Among the geological results, however, which Mr. Hennessy thinks to be established by his investigations, we may mention one or two—that the stability of the axis of rotation of the earth will progressively increase, as solidification advances—that the thickness of the earth's crust cannot

* Jour. Geol. Soc. Dublin, vol. iv. pages 139 and 147.

be less than eighteen, or more than six hundred miles, (a result very different from that announced by other investigators;) and also with reference to the directions of great lines of elevations, depending on the action of the pressures of the shell, and nucleus at their surfaces of contact, that inasmuch as observation as yet has not proved the existence of a zone of mean pressure, the directions of these lines of elevation must be comparatively arbitrary.

We trust that Mr. Hennessy will continue these very important researches, and extend their application to the explanation of geological phenomena.

I alluded last year to the promised "Manual of Scientific Enquiry," intended to be published by the Board of Admiralty, for the use and benefit of the officers of the naval service. This work has since appeared, under the able superintendence of Sir John Herschel; and in addition to the subjects more immediately interesting to the geologist, (and which are ably treated by Mr. Darwin, in a valuable and very suggestive paper on geology, Mr. Mallet, our late President, on earthquake phenomena—a paper characterized by the ingenuity and simplicity of the processes recommended for observers, Sir Henry De la Beche, on mineralogy,) we have short papers on tides and tidal observations, terrestrial magnetism, hydrography, astronomy, zoology, botany, &c., which together furnish an amount of information regarding the principal points deserving of observation, and the best methods of observing, that cannot fail to contribute largely to the progress of knowledge.

The connexion also of physical geography, with geological structure, is daily becoming more acknowledged and insisted upon; and the republication, in an improved form, and in an English translation, of Humboldt's "Aspects of nature," may be regarded as one of the evidences of this. We have also had a translation of Guyot's lectures, entitled, "The Earth and Man," and containing some original and eloquently expressed views.

The constant recurrence in foreign works, in the accounts of travellers, or in the descriptions of geographers, of very different and very various standards of measure, for the notation of vertical heights, must have been a frequent source of annoyance to every student. Thus, elevations will be found stated in English, in Paris,

or Berlin feet—in metres, &c. &c., so that long, and sometimes troublesome calculations are required before any comparative results can be obtained. The desirability of some general standard being adopted, is, therefore, too obvious to be questioned; and it is with great pleasure we would direct your attention to a valuable communication by Miss Colthurst, presented to the Royal Geographical Society by Mr. Greenough, in which she has adopted and carried out this idea of a common standard, to which the measures of different countries can be reduced. The standard assumed by Miss Colthurst is the geographical mile taken at the equator; this being a fixed quantity universally known, and dependant upon the figure of the earth itself. By dividing each of these miles into one hundred parts, each part is equal to 60¾ English feet; and taking five miles, or five hundred of these degrees or divisions, Miss Colthurst has constructed a scale from which, by simple inspection, the relative values of any elevations expressed in English, French, Bavarian, Danish, Swedish, Dutch, Spanish, Austrian, or Prussian feet, or Roman or Portuguese Palms, can be ascertained, as well as their value in the natural scale, adopted as the common standard.

It only now remains to apply a similar process to depths below, as well as to elevations above, the same level; and a general, simple, uniform, and philosophical term will be had as the standard to which all vertical distances shall be referred; the advantages resulting from which would be so great, that its general adoption is much to be desired.

The application of physical observations of another kind to geological research has been pointed out by M. Daubree,* who has reduced his long continued observations on the temperature of springs in the valley of the Rhine, at various heights above the sea, and springing from various rocks. He states as among his results, that springs at the same altitude have nearly the same temperature—that the decrease of temperature corresponding to elevations is not uniform—that the excess of temperature above that of the air increases with the elevation as it does with the latitude—and that all those springs which have a mean temperature more than 2° cent., above that of the place whence they arise, are from faults, or lines

* Annales des Mines, tom. xv. 4e serie, page 459.

of dislocation. The author, from these facts, is led to think, that the thermometer would form to the geologist, as it does to the mariner, a most useful instrument, in deciding the presence or absence of any fault in this way.

I have thus, gentlemen, very briefly, and very imperfectly laid before you a sketch of some of the most important communications brought forward during the past year, tending to advance the progress of our study. It would be impossible within the limits of an address to give even the slightest outline of all that has been done. The literature of geology so rapidly increases, that I cannot pretend to have even the time or the opportunity, busily engaged as I am, of becoming acquainted with such publications, much less the ability of laying clearly before you their contents. It would, besides, be but idle presumption in me to lay claim to such acquaintance with the numerous subjects which tend to illustrate our widely extended science, as would enable me to apprehend their full value, and succinctly to extract it for your information. I trust I have, however, been able to indicate a few of the more important subjects on which the attention of geologists has been fixed during the year; to shew some, at least, of the additions which have been made to our knowledge, and thus, to satisfy you that geologists have not been idle; that geology has not halted in its advancing progress; and that deeply as we have drank at the well of truth, its sources are still unexhausted and inexhaustible. And I shall, in however slight a degree, still certainly, have contributed to such progress, if I have been enabled to indicate, at the same time, any of those points on which additional evidence or illustration may be derived from Irish geology, and have thus stirred up to emulation in the race some of those I now see around me.

But, before concluding, I must crave permission, warmly and heartily to express my sincerely felt obligations for the high honour conferred on me, by the appointment to preside over you, and more especially at a period so critical in the history of the Society. That it was so, has made me regret that you were not guided by some one of more experience, and having more leisure at his disposal; while at the same time, the difficulties of the post only rendered the selection to fill it the more honourable.

But, gentlemen, its duties never could have been discharged without the cordial and kindly support and aid I have received from each and every member of your Council and Officers, and of the Society. The same partiality which led to my selection, has favourably acknowleged my weak efforts for your benefit, and overlooked my deficiencies; and the heavy debt of gratitude, which I had already incurred during my intercourse of many years with the Society, has been only increased by the more marked kindness, (if such were possible,) I have experienced as your President. It is also a great gratification to me, that by your allowing me to resume my former position as Secretary, in which I feel that my services can be of more advantage to your Society, you have given me another proof that my efforts, however feeble, have been received with kindness, and that my willingness and anxiety to promote your interest is not doubted, whatever my ability to accomplish those wishes may be.

It is now, gentlemen, my duty to resign this chair to Colonel Portlock, whose name is essentially connected with the progress of Irish geology—a well known and long tried friend to the Society—and under whose able guidance we cannot fail to advance. With this conviction, gentlemen, of the advantage which must accrue to the Society from the change, the duty of resigning would always be a pleasant one; but it is to myself a source of peculiar pleasure, when I find in the successor you have elected, him under whom I myself first used the hammer; my former master, my former and my present friend, to whose kindness I have been much indebted, and to serve under whom again, will recall some of the fresher enjoyments of my earlier years.

March 13th, 1850.—"On the rocks in the vicinity of Balbriggan Co. of Dublin;" by PROFESSOR OLDHAM, F.R.S. Secretary of the Society.

IN this communication, the author described in detail the mineral character and geological relations of the rocks extending from Skerries, northward, beyond Balbriggan, pointing out the succession observed, the disturbances and alterations produced by the intrusion of igneous rocks, and the fossiliferous nature of some of the series. The occurrence of these fossils was first made known by the geological survey, in connexion with which the results will be published in detail.

April 10th, 1850.—"On the Inequalities of the Sea Bottom, during the Tertiary Epoch," by LIEUTENANT-COLONEL PORTLOCK, R.E., F.R.S.

THE most striking characteristics of modern geology are its rigid adherence to facts, and its appeal to natural and speculative causes. It is thus that we are led from the present to the past, by a chain of inductive reasoning, and that we compare the doubtful of the past with the certain of the present time, rather than, by reversing this rational process, endeavour to build up a theory of the past, and then to bend the present into a conformity with it. Proceeding upon this truly philosophic principle, I may observe, that nothing is better known than the great inequality of the sea bottom, and that more especially in bays and river estuaries. The presence of sand bars, and of mud banks, the deep water of channel courses, though bounded by shallows, and the frequent variation of such channels, either by the silting up of one channel, or the scooping out of another, need little comment or illustration. These inequalities, and their variations, due to the varying forces, (either in amount or direction) of the marine currents, which are the great agents in the distribution of detritic matter, are not confined to our present ocean; and it is my principal object, therefore, to exhibit them in the sea bottom of the epoch antecedent to the existing one—namely, the tertiary. The tertiary strata of England are principally known from the great basins of London and Hampshire, and the most re-

markable division of them has acquired the name of London clay. As my present object is not so much the description of geological peculiarities, as the exhibition of physical phenomena connected with these strata, I shall simply observe, that the identity of character of the London clay, and the plastic clay under it, both in the London and in the Hampshire, is most remarkable. The one is, in both localities, a blackish blue, and the other a brownish red clay, and hand specimens, taken from both localities, cannot be distinguished from each other. In like manner, there is a similar interstratification of sandy strata, so that these basins have, like that of Paris, been found to be, and used as reservoirs of water. The London clay is much less broken up by sand beds than the plastic clay, and the water obtained by filtration, through those beds, is usually so impure, from the presence of mineral matter in solution, that it can rarely be applied to domestic purposes. The water obtained, on the contrary, either from the sand beds interstratified with the plastic clay, or from the surface of the chalk underlying it, is pure, and therefore palatable. The numerous artesian borings, both in the basins of London and Paris, have made these facts well known, but as yet no distinct chart of the borings, exhibiting the varying depths of the strata, has been published, although there can be little doubt that it would be a most interesting document. Taking advantage of the similar relations of the strata in the Hampshire basin, borings for water have, though more rarely, been made; and the application of the principles on which they are made, for public purpose, brought the matter under my notice at Portsmouth, and specially drew my attention to the great variation in depth of the respective strata. Some years ago, an artesian well was formed in the victualling yard, near Gosport, and an abundant spring was met at the depth of three hundred and twelve feet. In this section, a yellow clay was at the surface, and a remarkable bed of clean sand, thirty-one feet thick, occurred at forty feet from the surface; at ninety-four feet a small spring occurred in a bed of sand, two feet thick, and at one hundred and nineteen feet commenced firm homogeneous clay, the first bed being eighty-seven feet, and the second one hundred feet thick, a bed of shelly sand, three feet thick, separating them. In the borings, an occasional hard stone was met with, but little else to disturb the uniformity of the deposit.

I have no means of testing the exact nature of the deposits of this boring, but I am inclined to think that the loose clays and gravel near the surface, were post tertiary, and that the two great beds constituted the mass of the London clay. With this section before us, and the knowledge that another artesian boring, at Haslar hospital, had been also successful, it was proposed to obtain water for the Block-house Fort, about one mile and a quarter from the Clarence yard, by an artesian well. In this section, eighty feet consist principally of gravel, corresponding to the shingle beach of the present sea, and only broken by a little sand and silt, a small bed of oysters (the recent species) occurring at the depth of fifty feet. The London clay now commenced, and was here divided into three great beds, the two first separated by sixteen feet of dark sand, which yielded bad water, the upper bed being about fifty-eight feet, and the second sixty-eight feet thick. The lower bed was forty-six feet thick, and separated from the one above it by a bed of sand, eight feet thick, which, however, yielded no water, and was probably, therefore, entirely enclosed by clay. The lower bed was occasionally also sandy, and when passed through a bed of clean sand, twenty-four feet thick was met with, and a supply of good water. The borings here, therefore, were successful at three hundred and ten feet, or nearly at the same depth as in the Clarence well, though in the distribution and character of the strata passed through, there were many striking variations. In the Haslar well the water was obtained at a somewhat less depth, but I am not aware of the nature of the successive beds.

The position of the Block-house well, as compared to that of the Clarence, was in the direction of the dip of the underlying chalk, and the uniformity of depth at which the water was found, seemed to exhibit a tolerably level bottom, at the time of the deposition of the sand bed which produced it, although the variations of the subsequent beds indicated considerable modifications in the course of their deposition. The general deduction, however, seemed to be a fair presumption, that a boring proposed to be made in one of the basins at Portsea, and nearly in the line of strike of the chalk from the Clarence well, should yield water at about the same depth, the distance being about two miles and a-half ; and it was determined by the Board of Ordnance to apply the money voted for a tank to another artesian well.

At the surface no shingle appeared, but after passing through a little superficial clay and sand, the London clay was entered, and the borings continued in it for a depth of more than five hundred feet; when the plastic clay appeared, a few inches of hard sand, yielding no water, and therefore isolated or enveloped in the clays alone separating them. This clay continued, without any intercalated sand beds, being one uniform mass, to the depth of six hundred and ten feet, when the borings entered the chalk, and water rose in the bore-hole to about three feet from the surface. In this boring, therefore, all the sand beds had disappeared, and the two great deposits of clay were found almost in immediate contact, shutting out thereby the supplies of water. It will be observed that, in this locality, both the London and plastic clays had acquired an unusual development, and though such an accumulation may have been partly aided by local depressions in the surface of the underlying chalk, the consequence either of wear or of faults, it is manifest that the continued deposit of clay, during the whole of the plastic and London clay epochs, requires some other explanation. It is, indeed, highly probable that several causes have co-operated to produce the effect. For example, whilst a depression in the chalk may have led to the unusually deep deposits of the plastic mud, the sands may have formed a beach or bank, whilst the deep channel continued to have a mud bottom, and that this channel was subsequently silted up in the London clay epoch—and, finally, that the London clay covered over the sand, and formed a shallow basin. Doubtless, as shown by other partial sand beds, there were frequent variations in the currents and silting up forces; but such were only consistent with what is still observed in this and every other bay, subject at once to deposition from a river, and to tidal action; and, in like manner, the varying depths of the several deposits are in conformity with the existing inequalities of the sea bottom. I shall only, in conclusion, repeat the observation, that a careful investigation and tabulation of the results of borings, would throw a most important light on the condition of the sea bottom at successive epochs.

Lieutenant-Colonel Portlock communicated to the Society a letter he had received from his relative, Mr. Richard Rubidge, now re-

siding as a medical practitioner in the Cape country. The object of Mr. Rubidge is to describe a remarkable district, consisting of sandstone, marl, and shale, which is bounded on the north by the Zeurberg range of quartzose and porphyritic rocks, and on the east by similar rocks. These strata appear to have been deposited in a bay, are but little disturbed, and are about eight hundred feet thick.

Fossil wood is found in considerable abundance, and sometimes of great size, Mr. Rubidge having measured one tree, thirty-six feet in length, and two feet in diameter. Near the Sunday River vegetable impressions are also abundant; the fossils are not, however, limited to this class.

As Mr. Rubidge found in part of the deposit several genera of marine molluscs, and as the genera trigonia, gryphœa, &c., occurred amongst them, he considers himself justified in referring the deposits to the lias, or, at least, to a portion of the oolitic series.

The fossils will be brought before the society, in a more detailed manner, by Lieutenant-Colonel Portlock, in a future communication.

Mr. Rubidge further states that, on the faces of the Lias Cliffs, and in the gullies worn by the torrents, he found the bones of small rodent insectivora, and birds in great quantities. The skulls of the rodents he considers very remarkable, as they are too large for a mouse or rat, and he is not aware of any existing South African animal to which he can refer them. Many of the bones do belong to mice, rats, bats, &c., but it is very difficult to account for their existence in such vast quantities, since they are not broken, as would be the case, had the animals to which they belonged been brought to these places, and there devoured by birds of prey. In one spot, a gully in the alluvial soil, between the Sunday and Bushman's Rivers, the accumulation has been so great that bushels of bones may be collected, the largest of which belonged to animals larger, indeed, than a rat, though still of very moderate size. Mr. Rubidge speaks of an intended visit to the coal formation, near Shilih, which is in the land lately taken from the Kafirs, and the Society may therefore, ere long, expect another communication of much interest.

May 8th, 1850.—"Observations on the neighbourhood of Belfast, with a description of the cuttings on the Belfast and County Down Railway;" by James Mac Adam, Esq. F.G.S., Queen's College, Belfast.

The Belfast and County Down Railway runs from Belfast Lough to Strangford Lough. During the time of its construction, I took frequent opportunities of examining the cuttings; and having discovered some phenomena that were worthy of investigation, I was led to extend my examination for a short distance into the neighbouring country, confining my observations almost entirely to the post tertiary formations.

Referring to the map of this part of Ireland, we observe that the town of Belfast is situated at the extremity of Belfast Lough, which sheet of water is placed between the Counties of Antrim and Down, being not only, politically, a division between them, but, physically, a separation of two geological districts, each offering distinct features and phenomena. That of Antrim, on its north side, presents formations of trap, chalk, and other secondary rocks, which frequently exhibit steeply escarped fronts; that of Down, on the south, is composed of greywacke, having in a few places the edges of the lower secondary rocks resting upon it, but never showing those escarpments which are so remarkable in the district opposite, and which impart such a magnificent character to the scenery of the Antrim coast. The rock underlying the bed of the Lough is sandstone. (See plate.)

Proceeding from Belfast Lough into the interior of the country, we find the separation of these two geological districts continued in the valley of the Lagan. This valley extends from near Moira to Belfast, having on each side the same geological formations, and in the same order as they occur at the extremities of the Lough. The river Lagan finds its way into this valley between Dromore and Moira, having taken its rise in the greywacke district of Down. Its breadth is very insignificant, but its length must be considerable, as it has a serpentine course. It empties itself into Belfast Lough close to the town, and is there a tidal river, the tide flowing up it to some distance, and causing a difference in its body of water at different times of the twenty-four hours. Very extensive new quays are just now completed on both sides, which confine the river within their boundaries, whereas formerly at high tide there was a great

space at the end of the bay next the town covered with water, and at low tide, on the contrary, there was a disagreeable landscape of mud banks, that rendered the neighbourhood very displeasing to the eye. A spectator on the neighbouring hills could observe the river wending its circuitous way through these mud banks at low water; at high tide it required very skilful pilotage to bring vessels up to the town, without running them aground; but the improvements at the mouth of the Lagan, that have been recently effected, have produced a great change. A straight channel has been cut for the river, so that vessels drawing ten feet at low water, and eighteen feet at high water, can reach the town with the greatest ease. The mud banks, which have been in a great measure reclaimed, are now useful dry land, and are becoming gradually covered with buildings. The Lagan brings down a quantity of alluvial matter, which is deposited in the bends of its course, particularly near its mouth. This may be well observed at the Queen's Bridge, or as it is commonly termed, the Long Bridge of Belfast, where an alluvial flat may be seen at both sides of the river. On the County Down side, the tract occupied by the suburb called Ballymacarrett, has been plainly formed from the deposit from the Lagan, mixed with silt. This tract is bounded on the east by a small river, called Con's Water, immediately above which is a terrace of gravel and sand, running on towards the south-west, and proceeding up the right bank of the river Lagan. On the Antrim side, a similar tract of alluvion extends to the Botanic Garden, where there is the commencement of another terrace, similar to the one opposite, and extending inland for a considerable distance; so that in this part of its course, the river Lagan flows between the two gravel ridges or terraces. (See plate 1.)

There are several smaller rivers that flow through the ground on which Belfast is built. The chief of these is the Blackstaff, to which I wish more particularly to direct attention, although generally a very insignificant stream, except in time of great rains, when it overflows its banks to a considerable extent, and to the great annoyance of the neighbourhood. It empties itself into the Lagan; its original embouchure, some time in the last century, was altered, and a straight cut was made for it, which alteration has only served to make the river little better than a nuisance, and latterly much complained of, as producing unhealthy exhalations. This river has evi-

dently been much larger at one time than at present, as in examining the ground on each side of it, the bed of a former river is plainly discernible, the present one being a mere thread of water in dry seasons, that has cut its path deeper in the original bottom; but in wet seasons, when the water in it accumulates, the expanse on each side will give some idea of what the river once was; it has evidently been a great drainer of the surrounding country, bringing in its waters a quantity of mud, which being deposited upon silt and sand at its mouth, has, in all probability, contributed to form a great part of the tract on which Belfast is built. In digging in the streets and foundations of that town, silt and sand are constantly met with—very often beds of shells, all of living species, and marine peat.

Since the Blackstaff has diminished in size, the depositions of mud from it have manifestly diminished also, and the increase about the town has been latterly due to the Lagan, although all the small rivers have been observed to furnish their quota of the general mass. It is curious likewise to observe the effect produced by an increase of population. The small rivers bring down greater quantities of animal and vegetable matter, and the more mixed with mud, as the neighbourhood becomes the more inhabited. Within the last half century there has been a great increase of alluvial deposit upon the sands of the bay near Belfast, partly from this cause, and partly from the planting of a great number of trees on the north side of the Lough, which have sheltered the sea wrack, that had been previously blown to a distance. This wrack is the means of retaining the fine muddy particles, and thus forming new land. The straight cut, before mentioned, that was lately made for the river Lagan, has caused the reclaiming of several of the mud banks, and excavations have been made in them in connexion with the harbour improvements. These excavations exposed to view many beds of shells, all of recent species.

The deposition of mud on the County Antrim side has been more rapidly transformed into dry land, owing to the sea being kept out by the embankments of the Belfast and Ballymena Railway, which runs on that side of the bay. Bearing in mind, that it was the sheltered sea wrack that contributed so much to the formation of this mud deposit, and looking up at the trees that composed the shelter, we perceive that they are planted upon a ridge or terrace of

a very marked character, rising near the shore, frequently with a steep face, to fifty or sixty feet above the present sea level, then rising gradually inland, attaining a breadth of more than a mile, and ending at the mountain side. A part of the road from Belfast to Antrim passes over it at different levels. Its substratum is sandstone, covered with clay, through which local gravel is sparingly distributed, with occasionally marine shells of existing species. It may be traced from Carrickfergus to Belfast; but near the latter it is more escarped, as may be well observed from the low road along the bay. It continues into the higher parts of Belfast, having upon it the Barracks, the old Poor-House, and a long line of streets. Near the old Poor-House, and in many other places, its junction with the low ground can be well observed. The market-place called Smithfield, lies immediately at the bottom of the terrace; and in this place, where West-street opens into it, some trunks of old trees were found in an excavation for foundations. They were lying in sand similar to sea sand, about five feet under the present surface. With these trees were also found shells, principally littorina and cardium. There was silt beneath the sand, and similar beds of silt and sand, frequently with large quantities of shells, are found in this low ground, at the same level everywhere throughout the town. Continuing our way, however, upon the terrace, rising thus above Smithfield, we pass into the Falls suburb, where many factories have been built upon it, and going onwards, we see its breadth well displayed at Springfield, and its escarped front very prominent at the Lunatic Asylum, and in various other places up the valley to a considerable distance inland. The clay upon the surface of this terrace is of variable thickness; we may in different places in its escarpment, where the surface clay is thin, perceive the sandstone cropping out under it, being a portion of the same sandstone, already mentioned, as occupying the bed of Belfast Lough. Through this sandstone many whyndykes are observed to pass, almost all in parallel directions, nearly north and south. (See plate 1.)

The river Blackstaff flows in a hollow at the base of this terrace, which is thus placed at the north or left side of the stream. On the right, or south side, another terrace rises, composed of gravel and sand, which extends also up the valley. This is the terrace mentioned already, as commencing near the Lagan at the Botanic Gardens. It

is of considerable breadth, having, on the side next the Blackstaff, the Union Work-house, the Deaf and Dumb Institution, and various other buildings erected upon it, and proceeding for a considerable way up the valley, opposite to the former ridge. To an observer on the neighbouring hills, this gravel ridge or terrace appears to divide the valley into two parts, in one of which the river Lagan flows, and in the other the Blackstaff—the former flowing between two gravel ridges, the latter having a gravel ridge on its right side, and a clay and sandstone terrace on its left. The ground at the bottom of these terraces of the Blackstaff is wet boggy meadow, often covered with water, and having a substratum that has plainly been a deposit from a river flowing into an estuary.

The gravel terrace that occurs on the right, or County Down side of the Lagan, has already been alluded to. It may be traced for a considerable way up the valley, as the other terraces; or rather, if we follow it coming down the river, we see it well developed, especially near the river's mouth, not far from the bridges; and it continues, preserving its character, to some distance below Holywood, where it becomes broken, from the intrusion of greywacke rocks. As stated before, it runs behind the alluvial tract on the County Down side of the Lagan. Immediately above Con's Water we can see it to great advantage at the first cutting of the County Down Railway, where it has a breadth of more than a mile, and proceeding along the upper road to Hollywood, its tolerably even surface, with but little undulation, is quite conspicuous. It rests against, or hangs upon, the greywacke hills that form the back ground; and the line of junction of the terrace with the hill can in many places be determined by the difference in the vegetation—that upon the gravel being much the richer. Viewed from the low road near the shore, it exhibits in many places an escarped front, as may be instanced at Richmond Lodge and Knocknagoney; and from this road, crossing the terrace at two places—at Bunker's Hill and at the entrance of the town of Holywood—we have an opportunity of observing from these points the ridge sloping down in a steep talus to the low ground. The gravel that composes it is much mixed with sand, which frequently becomes so abundant, as to cause the soil to be almost wholly composed of it; and where the surface of the terrace is uneven, some of the elevations are sand hills, like downs. The

sand in these hills is ferruginous, quartzose, and is much used for economic purposes. It may be seen in large quantity at the first and second cuttings of the County Down Railway, at Mount Pottinger, where the terrace comes near the upper bridge, and at Newton Breda, near the Church, where there are some curious sand hills surrounding a hollow that must have once contained water. In continuing our course along this ridge of gravel, farther up the valley, we find upon it numbers of small hills like tufts, locally termed Drumlins, composed of sand or gravel, or a mixture of both. If we cross the river Lagan again, to the County Antrim side, we find the same characters in the ridge upon that side of the river—a continuous ridge, with similar hills or Drumlins upon it. These hills have been already mentioned to this Society by our fellow-member, Mr. Bryce, in a paper published in the first volume of the Journal. That gentleman has alluded to the kind of gravel found in the Drumlins. This is, in a great measure, local gravel, consisting of trap, chalk, flint, sandstone, greywacke, quartz, green sand, mica slate, granite, and quartz rock. Of these materials, trap is the most abundant, chalk and flint very frequent, sandstone less common, perhaps from its friable nature, and green sand but rare, likely from the same cause; the greywacke and quartz increase in quantity as the gravel is nearer the County Down hills. Mr. Bryce has supposed the primary boulders to have been brought by a current from the north-west; and in his paper referred to, he has advocated this opinion, by arguments deduced from an examination of the drift generally over this part of Ireland. We may also start the hypothesis of a current from the north-east, as these primary boulders have some resemblance to rocks existing in Cantire in Scotland, and the opening of Belfast Lough is in the direction of that district. There may also be traced on the shores of the channel between Ireland and Scotland, the effects of former great currents in that direction. At all events they have come somewhere from the north, as the effects of a current to the south are everywhere visible. On ascending the County Down hills, above the grand terrace, we find the drift upon them to be chiefly greywacke and quartz, derived from the local rocks; but mixed with this are pieces of trap, chalk, and flint, that are found up to the very summits, an elevation above six hundred feet, which fact has been already mentioned in Mr. Bryce's paper.

Between Belfast and Comber there is a valley running about north and south, in which a branch of the County Down Railway is placed. The hills on each side of this valley are of greywacke, but the greater part of the middle of it is occupied by an immense deposit of gravel, rising often on the sides of the hills to an elevation of more than two hundred feet. There are many small knolls consisting of gravel mixed with sand, on each side of the railway; and the soil of the fields, towards the lowest part of the valley, is half composed of stones of various sizes, so as to present a curious appearance when newly ploughed. This gravel has the same composition as that already mentioned. Among it are many beds of sand, but not very pure. At Comber, the railway takes an easterly direction to Newtonards, going still through a gravel formation, the majority of the gravel hills adjoining being upon the north side. They become less frequent towards the south, on approaching Strangford Lough. Near Newtonards there is a change in the geological structure of the district. At the hill of Scrabo there is a very large development of sandstone, the age of which has not yet been exactly determined; and capping this sandstone is trap rock. On the flanks of this hill the superficial covering is sandy clay mixed with boulders, such as we observed before; but at this place there is much less of the sand and gravel, like that of the adjoining country. Some of the trap boulders are very large, and have evidently been derived from the summit rock of Scrabo.

The Belfast and County Down Railway consists of two branches —one to Holywood, a length of four miles, on the south side of Belfast Lough; the other to Newtonards, on Strangford Lough, going round by Comber, a distance of thirteen miles. The Belfast terminus is near the Queen's Bridge, and is erected upon ground that was till lately covered at high water, but has been reclaimed by the recent harbour improvements. The Holywood branch runs upon an embankment placed upon this alluvion. Within the last fifty years, there was a sandy strand between Belfast and Hollywood, that was sufficiently hard to be used as a road; but the increase of alluvion upon it gradually rendered it unfit to be travelled on. This branch terminates at Hollywood in a gravel formation, called the Kinnegar, which occupies a space of tolerably even ground, about three-quarters of a mile long, and one-quarter of a mile broad.

From its being used as a common, its peculiar features can be well studied. Its elevation above the low water mark is from ten to twenty feet; and it must have had formerly a greater extent, as its edges next the sea bear the marks of having been acted on by the waves, that are still gradually wearing it away. This low ground formation extends for a short distance along the bay to the eastward, having the lower part of the town of Hollywood built upon it. The gravel composing it contains the same materials as the Drumlins of the valley. There are also in it considerable beds of recent shells. (See plate 1.)

The branch to Newtonards starts from the same terminus at Belfast as the other, and runs along an embankment over the alluvion as far as Con's Water, immediately above which, it reaches the gravel terrace at Turf Lodge, where the first cutting occurs. I shall describe briefly the cuttings in order, calling this one No. 1. It is almost wholly in sand, having some veins of clay through it, with small quantities of fine gravel, such as we find upon the sandy part of the shore of the bay. A few fragments of shells were obtained from it, and its elevation above low water is between eighty and ninety feet.

No. 2 cutting is an almost pure sand, in which an increased number of shells were found.

No 3. Sand mixed with clay, having a few shells.

No. 4 is a shallow cutting through the extremity of a Drumlin. In it were several alternate layers of sand and small gravel, such as occur so commonly on sea beaches. The elevation is as before, between eighty and ninety feet. The gravel preserves the same character as mentioned above, there are many fragments of Antrim trap, chalk, and flint, mixed with the local drift of greywacke and quartz, and with some pieces of sandstone and granite.

No. 5 has much sand, having in it some markings, such as are produced by worms on a sandy shore. At the north end the sand is overlaid by a bed of sandy clay, containing much large gravel, and the two beds have a well marked line of demarcation between them. At the south end, on the contrary, a waving bed of sand is placed upon the clay. Broken shells were also found in this cutting.

No. 6 shows sand much mixed with clay, containing the same kind of gravel as the rest. At the north end a bed of clay containing

boulders, overlies a considerable quantity of sand, in which is minute size gravel, like what is frequently met with at Holywood; there is more clay at the south end. Through a part of this cut, red clay overlies what is locally termed blue-till, which would indicate a considerable thickness of clay at this place; and this cutting would seem to have been made not a regular gravel hill, but rather in a projection in the underlying clay, which might have been an island when the adjacent country was covered with water, before the deposition of the sand and gravel.

No. 7 and No. 8 contain a large quantity of sand.

No. 9 shows a variation from the other cuttings. Under a thick coat of overlying gravel, mixed with sand and clay, we observe a mass of trap rock, which is occasionally faintly columnar, of a very compact texture, not zeolitic, but containing much felspar; in it may be often observed crystals of glassy felspar. It is not unlike a trap that occurs in the Co. Antrim, at Carnmoney Hill, four miles from Belfast, and like it, containing chalcedony, and a black mineral supposed to be chlorophœite. This was one of the most important cuttings on the line. At the south end where it was commenced, was a quarry called Graham's quarry, which had been previously wrought for this trap, its quality as a building stone having been much esteemed. The quarry was filled up in consequence of the railway embankment, but previously the trap had been worked to some depth; its bottom, or lower surface having been reached in some places, it was found to rest on greywacke, exhibiting a junction rarely to be met with. The greywacke had a compact texture; but the most extraordinary circumstance brought to light, was the existence of marks upon it, resembling the ripple marks on sand-stones, a phenomenon of very rare occurrence in a rock so old as greywacke. Some of the trap in this cutting had a ferruginous seam in it like iron ore, which, on examination, was found to be merely a superficial streak. In the insterstices of the trap that was faintly columnar, there was found occasionally a substance, sometimes whitish, sometimes grayish, apparently caused by infiltration, and which is a very common occurrence in similar rocks. The superficial covering over this trap was not very thick, sometimes clay, sometimes sand mixed with the usual gravel; the clay may have been partly derived from decomposed trap.

Nos. 10, 11, 12, 13, are through gravel mixed with sand, and do not present any remarkable features.

No. 14. Under the surface is gravel, having in it some boulders, mostly trap, of a tolerably large size, and underlying this are sand and sandy clay. At the south end, the sand is very compact, resembling a loose sandstone. In this cutting were found recent shells and rolled lias fossils, in a tough blue clay, eighteen feet under the surface.

No. 15 has gravel as usual: a few shells were got here. From a hill near this, consisting of sand and fine gravel, some shells were also obtained.

No. 16 has in addition to the sand and gravel a number of trap boulders. I observed also among the gravel some pieces like variegated sandstone. In the lower part of the cutting is sand, which appears to go beneath the rails.

No. 17. Gravel and sands.

No. 18. The same. At the east end there is a thick stratum of gravel, like a beach, over sandy clay. I saw in it also a loose sand or compact sandstone. I got fragments of shells, chiefly oysters.

The country to the northward of these last cuttings has numerous gravel hills; to the south it slopes down towards Strangford Lough.

No 19 has the upper part through superficial clay, with the usual drift, among which are some large boulders, chiefly trap. At the west end, the soft sandstone may be observed; the east end has a close resemblance to a beach, having a layer of coarse gravel overlying sand mixed with gravel. At the west end the gravelly sand is of a dirty yellow colour, as if derived from disintegrated trap. I obtained some shells in this cut.

In the last three cuttings I observed an increase of greywacke and quartz gravel. We now approach the mountain of Scrabo, composed of trap, overlying a great mass of sandstone, which is much quarried for economic purposes.

No. 20 is an interesting cutting; it is in a dirty, red, loose sandstone, sometimes a little variegated, and showing bands of different shades, as if deposited under a sea, near the shore. There are through it a number of little flatted roundish masses of the same substance; the beds seem to be nearly horizontal, except near a whyndyke which crosses the railway, and which has changed the dip of the sand-

stone immediately adjacent, and also the colour of this adjacent sandstone to dark colour, with increased hardness, like some primary slates. Over the sandstone there is a very thick bed of boulder clay.

Shortly after passing this cutting, we arrive at the end of this branch of the railway, at the Newtonards terminus.

Although the examination of these railway cuttings, from their being mostly in gravel and sandhills, may not be interesting to the general observer, it is so to the geologist, as he obtains proofs of the sea having stood at a higher level than at present, and of its having been spread over the surrounding country. The disposition of the sand and gravel, as exhibited in the cuttings, is precisely what we every day witness upon a sea beach, where we find both regular and irregular layers of the like, according to circumstances. The small quantity of shells, and their frequent broken state, point out that a large quantity of drifted materials has been transported, by some cause or other, and that, in its passage, many shells must have been crushed to powder, so that few could be expected to have remained entire. The composition of the drift also demonstrates that a large portion of it has been derived from the north, and has become mixed with local debris. Sandstone was passed through between Comber and Newtonards, but in cutting No. 20, that rock was displayed to the best advantage, it being at the base of the hill of Scrabo. The summit of this hill is composed of trap, resembling that obtained in cutting No. 9, and in the thick bed of clay that covers its slope down to the railway, there are many trap boulders, evidently derived from the summit rock. No. 9 and No. 20 were the only cuttings in which rock was the chief material worked through, the others being made in transported gravel, sand, and clay, a loose sandstone occurring in some places under the roadway, in the line between Comber and Newtonards.

Having now given a description of the physical and geological features of this district, I am desirous of inquiring into the probable causes of such a deposition of gravel and sand as exists in the valley of the Lagan, the valley between Belfast and Comber, and the country about Strangford Lough. From the great uniformity of the composition of the gravel, it may be concluded that it was deposited under the same conditions, and also that the configuration of the

rocky part of the district was nearly the same as at present. This gravel was also partly derived from rocks, situated towards the north, and currents from that direction, or it might have happened that, according to the views of some geologists, icebergs drifting from the north may have brought the gravel with them, and left it at a distance from its present source. Be the cause what it may, it is evident that, in each particular locality, gravel has been rubbed off the rocks of the place by the action of water, in a liquid or solid state, at a former period, and that this has been mixed with other gravel derived from the north.

If we look at the long extent of mineral precipices presented by the east coast of Antrim, displaying, in many places, faces cut down almost perpendicularly, and that plainly indicate a greater lateral extension at former periods, we must conclude that this operation has been effected by some cause, not as yet traced out. If we go along the north side of Belfast Lough, we see a line of similar mural escarpments, terminating in the same abrupt manner, and which must have been formed in the same way as the others along the east coast, and which escarpments must have formerly extended farther to the south. A portion of those rocks has, consequently, been reduced to fragments, some remaining at the base of their mother precipices, but the greater quantity carried to the south, or, perhaps, a part to the east, outside the entrance of Belfast Lough. This lough, or the space occupied by it, must, at one time, have been partly filled with these fragments of trap, chalk, flint, and sandstone, as we now find them, and it is to this circumstance that I wish more particularly to direct attention.

If the water stood at a height seven hundred feet above the present sea level, it would have covered the hills on the County Down side of Belfast Lough. It is not necessary to conceive that there was so much additional depth of water; it was, perhaps, comparatively shallow. We have proofs that there have been accumulations of fragments of the Antrim rocks spread over the bottom of the lough to a great thickness, which must be consequently subtracted from the total height of the water. This accumulation of debris must have attained a height of six hundred feet, so that there might not have been upon it a greater body of water than is at present found in the lough. I have stated that fragments of An-

trim rocks are found in the County Down, at an elevation of above six hundred feet, and this is perfectly compatible with the hypothesis, that the mass of fragments at one time attained that thickness. In the progress of time the water wore its channel deeper, and, consequently, fell in level; the tops of the hills would thus become dry, with the gravel upon them, as we now see it. As time rolled on, the water would continue deepening its channel, and would become narrower. Suppose it fell to about two hundred feet above present low sea level, a margin of gravel would remain on each side, like old shores, and this exactly is what I have described as occurring on both sides of the lough, the gravel terrace at that elevation, on the Down side, corresponding with the clay terrace on the Antrim side. The water going down still lower, might possibly, by a slow descent, cause the margins to be less steep, and, consequently, produce a gentle slope, which we can observe on both sides, for some distance; but, again, coming down to about seventy feet above present low water, the marked escarped terrace, on each shore of the bay, indicates a further lowering of the water, and proceeding still downwards, we have the Kinnegar, at Holywood, generally about twelve feet above the low tide, plainly a portion of a large gravel mass that extended far into the lough, corresponding with which, in level, are a raised beach, to the east of Carrickfergus, and likely part of the ground on which Belfast is built.

The same reasoning may be applied to the appearances of the gravel formation between Belfast and Comber. The water must have partly covered the greywacke hills, which would appear as so many islands, when the water descended in level; and which water, wearing its way deeper, in the progress of time, would eventually leave the valley dry, as it now is, having found a lower bed in Strangford and Belfast Loughs. The occurrence of shells, in the railway cuttings, as well as in the neighbouring hills of the gravel formation, and the arrangement of sand and gravel, precisely like what is seen upon a sea beach, which many of their cuttings display to us, all testify that there is no necessity for calling in the aid of a violent catastrophe to account for present appearances. When a simple cause can explain, we need not apply to one that is complicated or recondite.

The valley of the Lagan would present the same conditions as

Belfast Lough. The two gravel ridges, through which the Lagan now flows, are evidently portions of one and the same terrace, and this terrace is the continuation of the one that we have traced along the County Down side of the lough, where it is on the same horizon with the clay formation of the opposite side. These gravel and clay terraces preserve the same relations to each other, as we proceed up the valley, so that, according to our hypothesis, the entire valley of the Lagan, along with the Belfast Lough, has been filled with gravel and clay, and covered with water comparatively shallow, which, gradually descending in level, has left its marks behind, in the appearances which I have described. (Plate 1.)

A work has been recently published by Mr. Robert Chambers of Edinburgh, entitled, "Ancient Sea Margins," in which he has recorded a great number of observations, principally made in the British Islands, for the purpose of ascertaining the different levels at which masses, generally of gravel, and for the most part arranged as terraces, have been found to occur. These deposits are not confined to the neighbourhood of the sea, but have been discovered in valleys and plains in the interior of the country. In many of the deposits shells have been found, in a great measure resembling those inhabiting the actual neighbouring seas. Mr. Chambers concluded from these observations, that the physical configuration of this portion of Europe was, at one period, very different from what it now is, and that also at that period the state of the animal world was not very different from what it is at present. There was a large extent, occupied by a sea, containing a number of moderately sized islands, and subsequently to the formation of these gravel deposits, either the land has been upraised, or the sea lowered in level, so as to present the actual extent of dry land. Mr. Chambers has noted and tabulated, with great care, the different heights at which these deposits occur, and by a comparison of a great number of observations, he has come to the conclusion, that there has been a perfectly equable shift of level from the higher to the lower elevations, and that there is no indication of any convulsive or fitful movement having taken place.

Without, in any way, binding myself to adopt Mr. Chambers's opinions, I must testify to the diligence with which he has followed out the investigation of this subject, and the service he has rendered

to science, by directing to it so particularly the attention of the physical geographer. From the district which I have described in this paper, he could have drawn many illustrations of his theory, as there are distinct proofs that the sea has, at different periods, stood in it at different levels; but whether this was the case with the entire mass of oceanic waters over the globe, or merely with an isolated portion of them, I consider that we are unable as yet to pronounce with any degree of certainty; we must compare the results of the inquiries of observers in different localities, before any general conclusion can be adopted. I am still inclined to adhere to the opinion, that it is not required to suppose that there was an upraising of the land, to account for the present position of the gravel and sand formations which I have described; their present place can be explained upon the theory, that the sea, which once covered them, has worn in them a channel for itself, is now found at a lower level, and has thus left them dry, as we now see them. The theory of elevation may be applied to mountain chains, and to explain the actual position of many of the hard, rocky masses of our planet, but if a simple cause is sufficient to account for some of the more recent phenomena, we must urge its adoption in the true spirit of philosophising.

The opinion that the sea was, at one period, shallower than now, and that it was widely spread over the surface of the globe, at a higher elevation, has been brought forward by several geologists, who have also pointed out that it has worn channels for itself, and that it has descended to a lower level, and, in many places, has become deeper, from its alteration of the superficial configuration of the crust of the globe. As bearing upon this point, I shall quote the following extract from the "Berichte uber die Mittheilungen von Freunden der Naturwissenschaften in Wien." 1846, p. 114:—

"M. Streffleur considers that an explanation may be given of the general and gradual lowering of the level of the sea, without having recourse to a diminution of the general mass of water, or to an elevation of the land. A diminution of the mass of water, by chemical means, is possible, and not improbable. But if we have recourse to mechanical means, we must then seek for a mechanical cause to account for the sinking of the sea, in a gradual manner, and with the quantity of water remaining constant. The rotation of the earth traces the furrows of currents at the bottom of the sea, and the bottom will become excavated in the deepest parts of these furrows, and between two currents an embankment or ridge is produced. The

particles of solid matter that are separated by the action of the water, in the bed of the current, are precipitated upon this intermediate ridge, and which increases in this manner until it reaches the surface of the water; in the meantime the bed of the current is continually becoming deeper. For so far the surface of the sea has not become, in any great degree, lowered; but as the daily tides bring solid matter to the embankments that are now beginning to rise above the sea level, and as these banks become wider, the sea begins to sink in those places where the loose materials have been heaped up by the currents. The ebb no longer brings back what the flood had thrown upon the solid matter above the level of the sea, and these embankments eventually become high and dry. It consequently happens that the waters, which were formerly shallower, and which covered a greater extent of the earth's surface than they do at the present time, have, in consequence of its rotation, become separated into portions of various extent, and that the general result has been higher continents, and deeper and narrower seas."

As large quantities of gravel occur in many parts of Ireland, at different heights above the present sea level, observers have many opportunities of examining for further proofs of the opinions mentioned in this paper. It is only by the comparison of a great number of observations that their truth or falsehood can be tested, and in this state I leave the subject to rest upon its merits.

In the supplement to this paper there will be found more particular details respecting the shells obtained in the gravels and sands of the district described.

"Supplementary observations on the neighbourhood of Belfast;" by James MacAdam, Esq. F.G.S. Read June 12th, 1850.

In order to render more complete the detail of my observations upon the recent formations in the neighbourhood of Belfast, I have made out lists of the shells that have been collected in different places, and at different levels.

The greater part of the town of Belfast, as was stated in my paper read upon the 8th May to this Society, is built on a flat consisting of sand and silt, with frequent beds of shells. These shells are of the same species as those found in the cuttings in the sand and mud banks, that were carried on during the progress of the harbour improvements. I made a large collection at different times; but not being satisfied with the variety of species which it afforded, I applied to Mr. John Grainger, a member of the Belfast Natural History Society, who had also made a very large collection, and during the time that the cuttings were most exposed, so that he

had opportunities of obtaining most of the varieties. From that gentleman I obtained the greater number of the following names. It is to be recollected that all these shells were found at or under low water mark, so that in point of level, they are to be regarded as the lowest deposit, and also the newest in regard to time; although in respect to geological age, I conceive there is no difference in those obtained at the various levels, *or at most very little.*

The following is a list of the shells found in the silt and sand of the Harbour of Belfast, and in the foundations of the town:—

Murex erinaceus,
Aporrhais pes pelicani,
Natica glaucina,
Nucula margaritacea
oblonga,
Trochus cinereus,
magus,
Patella vulgata,
Littorina tenebrosa,
neritoidea,
Lacuna crassior,
Purpura lapillus,
Cypræa europæa,
Rissoa ulvae?
Odostomia pallidula,
Scalaria Turtoni,
Cerithium reticulatum,
Nassa reticulata,
macula,
Buccinum undatum
var. carinatum,
Fusus antiquus,
Creusia verruca,
Pholas candida,
crispata,
dactylus,
Balanus, (two species,)
Vermilia,
Serpula,
Teredo norvegica,
Lucina radula,
flexuosa,
Artemis undata,
tincta,
Amphidesma Boysii,
compressum,
Anomia ephippium,
Ostrea edulis,
var. parasitica,
Pecten maximus,
opercularis,
varius,
Mytilus edulis,
Modiola tulipa,
Saxicava rugosa,
Syndosmya alba,
Pullastra decussata,
Lutraria elliptica,
oblonga,
Scrobicularia piperata,
Corbula nucleus,
Mya truncata,
arenaria,
Thracia convexa,
pubescens,
phaseolana,
Psammobia ferroensis,
vespertina,
Solen marginata,
pellucida.
Cardium echinatum,
edule,
exiguum,
Mactra subtruncata,
elliptica,
Venus laminosa,
aurea,
Tellina solidula,
tenuis,
depressa,
Montacuta purpurea.

The next locality for recent shells, ascending in level, is the Kinnegar at Holywood, which contains several beds of shells from fifteen to twenty feet in elevation. These are of the same species with those just mentioned, but the variety is not so great; however the specimens obtained were generally larger and finer than those got from the cuttings in the harbour.

The terrace behind Holywood, and which runs along the south side of Belfast Lough, and then inland, up the valley of the Lagan, preserves an average level of about eighty feet. I obtained shells from it at Knocknagoney, Richmond Lodge, Bunker's Hill, and Ballagh's farm, all of which places overlook Belfast Lough. The species were not numerous, but the same as in the deposit below—Ostrea, Cardium, Mytilus, Littorina, Tellina, Mactra, Pullastra, Pecten, Rissoa. They were often broken. I found similar shells in the continuation of the terrace up the valley; but their occurrence is more rare, as there are not many excavations in that part of the terrace, where they are elsewhere most generally to be found, and they are not likely to be got in the Drumlins, which have been opened in many places. I procured several at Milltown, a short way off Shaw's Bridge, and in some other excavations, caused by a new road in that neighbourhood.

I stated in my paper of 8th May, that the gravel formation of the terrace is found also in the valley between Belfast and Comber, in which the Newtonards branch of the County Down railway runs. At about the same elevation as above, I found shells in some of the railway cuttings, the species becoming still fewer—Ostrea, Pecten, Mytilus, Cardium, Mactra, Buccinum, Littorina, Trochus, Purpura, Turritella; and in the gravel on the north side of the railway, in its course from Comber to Newtonards, I found a few of these species also. I may again mention the rolled lias fossils obtained from the railway cutting at Comber; they were Gryphaea incurva, and Pachyodon Listeri, evidently brought by some current from the County of Antrim, and I observed that in this cutting several of the recent shells were also rolled.

At the same elevation on the terrace of the County Antrim side, I obtained several shells. I got a considerable number in an excavation at a villa called the Grove—Cardium, Tellina, Ostrea, Mactra, Nassa, Patella, Littorina, Cerithium, and some others in fragments,

of the species in the list mentioned above. I also got fragments at Fort William and Parkmount, and expect that future excavations will discover other localities.

Ascending in elevation to what may be considered a higher terrace, (or perhaps more correctly, the higher part of a gently sloping gravel ridge, that rises from the terrace already mentioned, so that we may regard both as the same formation,) we find on the County Down side, near the Knock, and not far from No. 3 cutting of the County Down Railway, a bed of clay in a small river, apparently overlying variegated marl, and having over it a bed of gravel and sand. In the clay I found Fusus bamfius, Nucula oblonga, and another Nucula, the species not determined, with a few fragments of other shells. The elevation of this bed is about one hundred and fifty feet, and it is a very remarkable occurrence, being quite different from the other formations in which shells were obtained. I shewed the clay and shells to Mr. Hyndman of Belfast, who, along with Mr. Bryce, had published in 1842, an account of a deposit of shells found in the excavation for the Belfast Water Works, on the Antrim side of the Bay, at an elevation of about one hundred feet; and that gentleman at once recognised the perfect similarity of the two deposits and their contents, although situated more than three miles apart. The stratification at each place was also the same; and it is to be recollected, that variegated marl is of very rare occurrence in the County of Down. Messrs. Hyndman and Bryce's paper was copied into Portlock's Report of the County of Londonderry, p. 738.

I found fragments of shells at the Stye Brae, in Gilnahirk, the highest part of the gravel formation, at about two hundred feet. This place is about a mile from the Knock, and at it the gentle slope of the gravel terrace commences, from whence it joins the adjoining greywacke hill, and its course towards the bay can be seen to the greatest advantage.

The above is what I wish to add to my observations in the paper of the 8th May. My researches in the shell localities must necessarily be very incomplete, as my attention was not directed to them until I had examined the County Down railway cuttings. I have no doubt that future operations in the neighbourhood will bring to light other phenomena of the same character, and highly deserving the consideration of the geologist.

"On a Tabular View of the Order of Deposition, and Geological Succession of the Groups of Stratified Rocks;" by CAPTAIN R. SMITH.

CAPTAIN R. SMITH exhibited and explained the construction and objects of a Tabular View of the Stratified Rocks, which he had constructed, designed to indicate at a glance the chronological succession, the mineral character, and the prevailing fossils of each subdivision, together with the localities where it is best seen, or most easily studied.

June 12th, 1850.—"On the Minerals of the Auriferous Districts of Wicklow;" by WILLIAM MALLET, ESQ.

THE circumstances attending the original discovery of native gold in the beds of some of the streams of the County of Wicklow, have been already often detailed, and will therefore need but a brief repetition. The source of the auriferous streams is the mountain Croghan Kinshela, whose summit forms a portion of the boundary between the counties of Wicklow and Wexford. The stream from which most of the gold has been obtained rises on the north-east side of this mountain, and flowing down one of the glens with which that part of the country is intersected in almost every direction, joins the Aughrim river, a little above the confluence of the latter stream with the Avonmore. It receives several smaller streams at different parts of its course, in all of which, *some* gold appears to have been found, though in general in such small quantity as not to repay the cost of its extraction. Small pieces of the precious metal had been accidentally found by individuals, at various times preceding the year 1795, in which year great numbers of the peasantry, excited by the account of some large pieces which had been casually discovered, began to search for gold, though in a very unskilful and desultory manner. About six weeks afterwards, the government

took possession of the stream, and stationed a detachment of militia on the banks to keep away the peasantry. The latter had, however, obtained about eight hundred ounces of gold during the short period they continued at work. The government then took the washings into their own hands, and continued the search for about six years, not confining themselves merely to washing the alluvial matter constituting the bed of the stream, but also driving a level into the side of the mountain in search of the vein in which the gold was supposed to be imbedded. These trials, however, proved unproductive, and the expense exceeding the value of the gold obtained, government abandoned the workings in 1803, since which time a few of the peasants of the country round, have occupied themselves irregularly and at intervals, in rewashing the sand which had been carelessly turned over before, and from which they still obtain some gold in small grains, but scarcely sufficient to afford them the means of subsistence. About six or seven years ago, some further attempts in search of gold were made by a company organized for the purpose, by cutting extensive trenches at right angles to the course of the Ballinvally stream. These, however were, also unsuccessful, and the washing is again solely carried on by a small number of the peasants.

Although this part of the country, since it has been known to be auriferous, has been an object of some attraction to mineralogists, but little attention seems to have been directed to the other minerals which are to be found accompanying the gold in the alluvial deposits. These, however, are interesting, not only from their number and variety, but also from the occurrence amongst them of some of the rarer species, which have not, I believe, been noticed in any other locality in Ireland. The following minerals were obtained from a considerable mass of sand and gravel taken from various parts of the bed of the principal stream, and examined by passing it through sieves of different degrees of coarseness, separating the minerals of different specific gravity by washing, and finally examining each portion carefully with the aid of a lens, and picking out the individuals of different species with a forceps. I have also subjected to analysis a few of the minerals whose composition appeared interesting to determine. The following list comprises all the species which I have been able to detect, but probably does not by any

means exhaust the number of those which actually exist in the sand :—*

Gold,	Galena,
Platina,	Sulphuret of Molybdenum,
Tinstone,	Sapphire,
Magnetic Oxide of Iron,	Topaz,
Micaceous Iron,	Zircon,
Red Iron Ochre,	Garnet, (2 varieties,)
Hydrous peroxide of Iron,	Quartz,
Common Clay Ironstone,	Prase,
Iron Pyrites,	Augite,
Titaniferous Iron,	Chlorite,
Wolfram,	Felspar,
Oxide of Manganese,	Mica.
Copper Pyrites,	

GOLD.—This mineral occurs here in probably its most beautiful form. It possesses the true golden yellow colour and metallic lustre which characterise the metal, and, owing to the attrition to which it has been subjected, generally presents a beautifully brilliant surface. It occurs in grains of all sizes, from the smallest spangle up to a mass weighing twenty-two ounces, the largest hitherto found. The specific gravity of some small grains I found to be 16.342. The analysis of these grains gave

Gold,	92.82
Silver,	6.17
Iron,	.78
	99.27

This is equivalent (neglecting the iron) to $8\frac{1}{4}$ atoms of gold and 1 of silver.

PLATINA.—Mixed with the gold are some very small flattened grains of a white colour and metallic lustre, which, as far as their minute size permitted me to examine them, appear to present all the characters of platina. They are infusible before the blowpipe, and insoluble in nitric acid, but dissolve in aqua-regia. Their

* I have since observed, in addition to those here mentioned, Arsenical Iron, in small fragments, and also Spinelle. The latter occurs, in very small grains, along with the second variety of garnet, from which it is readily distinguished by its peculiar purplish-red colour.

occurrence intermixed with the gold when all other minerals have been washed off, is a proof of their high specific gravity.

TINSTONE.—The occurrence of this mineral in the sand is mentioned by Weaver in his reports on the gold stream-works, but he does not seem to have been at all aware of the large quantities in which it exists. From the comparatively small portion* of sand which I had an opportunity of examining, I obtained about 3½ pounds of stream tin, a portion of which being reduced, yielded an ingot, which, when refined by a second fusion, is hardly inferior to the finest grain tin.† Should this mineral be found in the mass of the sand in a quantity at all approaching that in which it existed in the specimen from which this was obtained, it would probably richly repay the labour and expense of its collection and smelting. From the small quantity in which other minerals of high specific gravity exist in the sand, and the constant supply of water, very little difficulty would be experienced in separating it from the rest of the sand, and the almost total absence of arsenic and lead would render it extremely easy to obtain from it metallic tin of the very first quality. The mineral itself occurs in grains varying in size from fine sand up to pebbles of half an inch in diameter, and for the most part of a dark brown colour, with some fragments of various tints of yellow and red; some presenting the peculiar appearance to which the name "wood tin" has been given. All these varieties are slightly translucent, some of them highly so. Many of them present distinct traces of their original crystalline form; the principal varieties observable being the primitive obtuse octohedron, the same with a short four-sided prism interposed between the two pyramids, and the latter of these with various truncations of its angles and edges. The specific gravity of some picked crystals was 6.753. A careful analysis of this tinstone gave, as its constituents—

Peroxide Tin,	95.26
Peroxide Iron,	2.41
Silica,	.84
	98.51

* The exact weight of the specimen examined I do not know, but I think it certainly did not exceed 150lbs.

† The specimen smelted in this experiment yielded about 61 per cent. of tin, but more would be obtained on the great scale, as in this case no pains were taken to extract the tin remaining in the scoriæ.

I believe that it also contains a minute trace of columbic acid, but of this I am not quite certain.

Magnetic Oxide of Iron is found in the state of fine sand along with the gold and other heavy minerals, when the lighter portion of the sand has been removed by washing. It does not, however, here constitute such an important constituent as it does in the greater auriferous deposits, as those of California and the Oural,* but exists in comparatively small quantity.

Micaceous Iron.—This mineral occurs in very large quantity, both in the bed of the stream, and in the alluvial deposits which form the banks on either side. In the latter it is sometimes found in very large rolled masses, and in the state of pebbles of various sizes it constitutes a considerable portion of the auriferous gravel and sand. It consists of extremely minute plates, which, under the microscope, sometimes exhibit the form of six-sided tables. It is of a steel gray colour, yielding a red powder similar to that from ordinary red hæmatite. Its specific gravity, determined in the ordinary way, was 4.486, but this is probably rather lower than the truth, owing to the difficulty of entirely removing air bubbles from the surface of the mineral when immersed in water. A very pure specimen yielded, on analysis,

Peroxide Iron,	95.72
Silica,	1.84
Alumina,	.98
Oxide of Manganese,	.49
	99.03

Red Iron Ochre.—This mineral is found massive in small pebbles of a bright brick-red colour externally, and dark brownish red fracture. It is very soft, and soils strongly like red chalk. In other respects it resembles the micaceous iron.

Hydrous Peroxide of Iron occurs in large quantity in the form of small cubes slightly rounded on the edges, and obviously derived from the decomposition of iron pyrites. Exposed to the blow-pipe flame in a closed glass tube, they decrepitate, and give

* Vid M. Dufrénoy. "Etude comparative des sables aurifères de la Californie, de la Nouvelle-Grenade et de l' Oural." Annal. des Mines, 1849. IVe livraison, p. 3.

off a good deal of water, and the residue in the tube appears to consist of almost perfectly pure peroxide of iron.

Common Clay Ironstone is also found in the sand, but in small quantity. It differs in no respect from ordinary brownish clay ironstone, except in containing rather a large proportion of oxide of Manganese, the exact amount of which, however, was not determined.

Iron Pyrites.—This mineral occurs in the form of small cubes, extensively diffused both in the pebbles of clay-slate, which constitute the largest portion of the auriferous sand, and in the rocks from which these pebbles have been derived.

Titaniferous Iron.—There are some small pebbles to be found amongst the sand, hardly to be distinguished by external appearance from the clay ironstone before mentioned, but of much higher specific gravity, varying from 4.3 to 4.4. These contain a large portion of titanic acid. I have not, however, made an exact analysis of them.

Wolfram.—This substance, which appears almost invariably to accompany the ores of tin, is to be found in the Wicklow sand, in small grains pretty extensively diffused, though not on the whole constituting any very large proportion of the deposit.

Oxide of Manganese.—This is found in small pebbles and fragments of reniform masses, externally polished by attrition, but, when broken, exhibiting very little lustre on the surfaces of fracture. They are of a bluish-grey colour, and uniformly massive, presenting no traces of crystallization. They are by no means pure oxide of Manganese, but contain a good deal of iron, and some earthy impurities.

Copper Pyrites occurs in very small quantity in minute grains disseminated through the sand. It also exists in a curious mineral compounded of micaceous iron and copper pyrites, which has been found at one of the shafts sunk in search of gold.

Galena is found in the rocks adjoining the banks of the stream, where there are now some shafts being sunk for the purpose of extracting it. It is sometimes to be found, though in extremely small quantity, in the auriferous sand itself.

Sulphuret of Molybdenum.—In one part of the stream, I found a few rolled grains of this mineral, but it does not appear to be extensively diffused through the sand, or to occur in any considerable quantity.

All the preceding minerals belong to the class of metallic ores, but the sand also contains a great variety of earthy minerals, some of which are very rare in this country. The first of these to be noticed is

Sapphire.—It is found in rounded pebbles of a beautiful dark-blue colour, but very nearly opaque, or at least only translucent on the edges. They do not present any trace of crystallization.* They possess quite the same degree of hardness as the specimens from Ceylon, scratching topaz, and even chrysoberyl with ease. The specific gravity of the only piece which I was able to obtain was 3.948. These pebbles are extremely rare in the Wicklow sand, but very few of them having yet been found.

Topaz.—This mineral is also very seldom met with in this locality. It is in colourless grains, which are principally remarkable from the very slight alteration of their form by attrition.

Zircon occurs in small rolled grains of a dull brownish red colour, and presenting in a slight degree the peculiar lustre which is so characteristic of this mineral. It exists in but *very* small quantity in the sand.

Garnet occurs of two different species.

1st—A mineral of a dark red colour, in grains almost exactly resembling pyrope, which, however, it does not appear to be, as some of the grains present faces belonging to the regular rhombic dodecahedron. It is very rare in the Wicklow sand.

2nd—Another species of a very much lighter colour, and in *very* small grains, never exceeding the size of mustard seed. Under the microscope, their dodecahedral form becomes visible, the edges of the crystals being slightly rounded. Their specific gravity is 4.196. Before the blowpipe, the phenomena due to Manganese are very distinct. They gave, on analysis,

Silica,	35.77
Alumina,	19.85
Lime,	Trace
Protoxide Iron,	38.07
Protoxide Manganese,	5.04
	98.73

* I have found in the finer portion of the sand a very small grain, consisting of two or three minute six-sided prisms of a blue colour, which appears to be sapphire, but its minute size precludes the possibility of determining this with certainty.

They therefore belong to the class of manganesian garnets. These grains occur in very large quantity in the sand, and are uniformly to be found along with the heavy minerals at a particular period of the washing.

Quartz is to be found in small crystals, and in amorphous masses of various sizes. It varies from transparent to nearly opaque, and generally occurs colourless, but is sometimes found tinged with various shades of yellow and brownish red. It is also occasionally intimately penetrated by chlorite, producing the variety to which the name Prase has been given.

Augite occurs in very small abraded crystals of a brown colour. They present the form of oblique six-sided prisms. They are to be found in but small quantity in the sand.

Chlorite.—This mineral occurs in very considerable quantity, principally imbedded in quartz and micaceous iron. It is quite similar to ordinary specimens from other localities.

Felspar and Mica.—Both these minerals are found in the sand, and are obviously the products of the disintegration of the adjoining granite, which resembles in every respect that which is found all through Wicklow.

The preceding list comprises all the simple minerals which I have been able to detect in this sand, the remainder of which consists of the detritus of the adjoining rocks, which are principally clay-slate and mica-slate. The greater number of the minerals here enumerated are mentioned by Mr. Weaver in his reports to government on the district, and which are to be found in the Transactions of the Royal Dublin Society; but some of them have, I believe, not been noticed before, at least I have seen no published account of the occurrence in this locality of Platina, Titanic Iron, Sulphuret of Molybdenum, Topaz, Zircon, the small Manganesian Garnets, or Augite. Hence it seemed interesting, while noticing these, to collect into a uniform and as far as possible complete list, all the scattered notices of the mineral wealth of this particular district, which are to be found in Mr. Weaver's papers already referred to, and elsewhere.

The principal point, however, with respect to the examination of these minerals, which appears to merit further and more particular attention, from some one better qualified for the task, is the fact of the

existence of Tinstone in such considerable quantity in these auriferous streams: a fact which would seem to indicate the probable existence somewhere in the surrounding district, of masses of the ore of this valuable metal of great extent, and possibly forming the continuation, on this side of the channel, of those vast deposits which have contributed to furnish occupation and support to the inhabitants of Cornwall for more than two thousand years.

"On the effects of lateral pressure in producing curvatures, in rock-strata;" by EBENEZER E. BARRINGTON, ESQ. C.E. Communicated by PROFESSOR OLDHAM, Secretary to the Society.

IT is not proposed in the following remarks, to enter into any enquiry as to the source or cause of such pressures or forces as may have acted on the stratified rocks forming the earth's crust, but simply to enquire what the result of the action of such forces will be, granting their existence.

The force so exerted endways on a stratum, or series of strata, may act in one of three different ways.

1. As an impulse; in which case the result would be, that it would communicate to the mass acted upon (neglecting elasticity, and supposing this mass not to be in contact with other bodies) a sudden velocity, equal to $\frac{M\,v}{M+M_1}$.

M representing the mass of the striking body; v, its velocity; and M_1 the mass of the body struck.

If this velocity be prevented by any obstacle, the body struck must break in pieces, unless the cohesion of the particles is able to overcome the motive force communicated by the impulse, in which latter case the effect depends on the elasticity. Indeed, even though the body were in empty space, or in a medium which generated but little friction, this suddenly acquired velocity, being first communicated to the particles nearest to the moving power, might cause them to separate, divide, or scatter from the further or more distant particles, in any case of insufficient cohesive power. But this is not important.

2ndly. It might be a simple force, of such a nature that its action must be slow; that is, to speak with reference to geological questions, that any velocity communicated by its means to strata, would, (since the masses moving must follow the masses moved, in order to continue the action,) generate such an amount of friction in the masses which exercise the motive power, as to diminish that power; and so by les-

sening the force in proportion to the rapidity of the action, cause a *gradual* change in the position of the beds acted upon.

3rdly. We can conceive a simple force applied to strata, such that it is not materially affected by its own action.

Now I conceive that the second case stated above, is that most frequently at work in the crust of the earth. If, however, our object be to determine the position of equilibrium, the third will obviously lead to the same results.

The mass acted upon may be also divided into three kinds. 1st, fluid; 2nd, solid; 3rd, laminated; the latter being considered as first, without lateral cohesion of the laminæ, and secondly, with a certain amount, but this amount very much inferior to that of the transverse cohesion.

1. Regarding the first kind, the fundamental principle of hydrostatics, that fluids transmit pressures equally in every direction, is well known.

2. In the case of a solid, the effect will be so modified by peculiar circumstances, that we shall dispense with the consideration of them as much as possible, and consider the simple case of a parallelopipedon of nearly uniform structure, acted on by a force uniformly distributed over one end to which it is applied. The result here would be, that a wedge would be broken off, making, according to one theory, half a right angle; by another principle, an angle somewhat greater, with the side to which the force is applied.

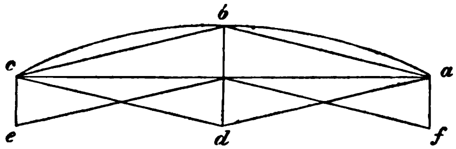
3. In the case of a laminated mass, the strata subjected to the force may be under three conditions: (a) isolated; (b) in contact with other rocks on *one* side; (c) in contact with other rocks on *both* sides.

Before proceeding, however, it will be necessary to consider the nature of the action of a force applied to the ends, or endways, of an infinitely thin lamina. Supposing the lamina to be mathematically *in the same plane*, and that the force acts in that plane, it is clear, if the particles of the lamina be supposed incompressible, that the force will be equilibrated. If, however, the lamina* be not exactly in the same plane, but slightly curved, as in fig. 1, the force applied at a, resolved in the direction of $a\,b$, will, together with the reaction of the point c, in the direction of the line $c\,b$, give rise to a force in the direction of $d\,b$, equal to $d\,b$, if $a\,b$ represent the component of the original force.

* In this theorem, the part of the lamina between a and b, and between b and c, is considered as possessing perfect rigidity, so as to be able to convey the force from a to b, and from b to c, just as if they were rectilinear instead of curved; and this for two reasons: first, because it is easy to show that the resultant will be greatest at the centre, (the curve being supposed symmetrical) and that the lamina would yield there first; secondly, that in the cases under which we shall consider the force as acting, the contiguous laminæ, or adjacent rocks, will effect the rigidity required.

N.B.—The force $a\,b$, strictly speaking, gives rise to a force in the direction $b\,c$, equal to $a\,b$ cos. $a\,b\,c$, and to a force perpendicular to $b\,c = a\,b$ sin. $a\,b\,c$; but this angle being supposed so obtuse, we have stated it generally as above, not meaning there to speak of the strictly exact values of the forces. If, however, the motion of b be prevented or resisted by a surface parallel to $a\,c$, then $b\,d$ and $b\,c$ will be the true values of the components.

Figure 1.



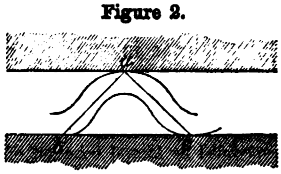
The other components of the applied force and of the reaction, viz.—$a\,f$ and $c\,e$, are also to be considered. They will cause the ends of the lamina to move towards f and e, with the same velocity, which is equal to one half of the velocity of the centre (b) in the other direction.

This is the result with a lamina in an isolated condition. Let us now consider the result in the second condition, when the lamina at a and c is in contact with a fixed surface, which constantly prevents the ends of the lamina from moving towards f or e. The result of this is, that the forces, $a\,f$ and $c\,e$, are counteracted by its resistance; while a force equal to $b\,d$ acts on the centre (b) in the direction of $d\,b$.

In the third condition (in contact with other laminæ on both sides) this force, $d\,b$, is met by the surface in contact at the other side, against which, therefore, the lamina exerts the pressure at b.

It is now easy to pass from the consideration of a lamina infinitely thin, to that of one of a finite thickness; for, as before, if the lamina be bounded by two parallel planes, to which the applied force is also parallel, this force must be equilibrated by its resistance, and can have no tendency to bend it; but if the bounding surfaces be curved,* and if the line joining the centres of gravity of the two ends cut either bounding surface, it is clear, that (as the forces, being equally distributed on their terminal surfaces, are equivalent to their sum acting at the terminal centre of gravity,) their effects will be to produce a *transverse resultant*, approximately proportional to the versine of the arc, cut off by the above line from the curve made by the intersection of a perpendicular plane through the centres of gravity with the lamina.

Figure 2.



Starting from this principle of a transverse resultant, we shall proceed to the general case of a laminated mass, i. e. a mass con-

* We suppose for simplicity, that the curved form of the lamina, when subjected to the force is such, that its intersection ith any plane perpendicular to the direction of the force, is a horizontal right line.

sisting of a number of parallel laminæ, acted upon by a force applied to their end, and consider it also under the above three conditions. We shall then see how a laminated mass is affected by lateral interminal pressure, in a manner, as it were, intermediate between that of the solid and the fluid.

1st. When isolated: this case, being one extremely unlikely to happen, we shall dismiss by saying, that before the result in the case of a solid mass would have taken place, the laminæ, owing to some trifling inclination or deviation from the plane in which the force acts, would be forced outwards by the transverse resultant mentioned above, which might be in a different direction for different laminæ, and so might cause them to separate in the centre, when the transverse resultant increasing with the curvature of the laminæ, the whole mass would rapidly give way.

If a certain cohesion existed between two contiguous laminæ, the mass would not give way, until the difference between the transverse resultants, which move the laminæ to each side, would be able to overcome the elastic force, if elastic, or otherwise the cohesion of the laminæ on their cross section, unless, indeed, the *least* of the two resultants were greater than the cohesive power on the longitudinal section, when the only extra effect of the cohesion would be, perhaps, to change slightly the point of separation.

2ndly. With rocks at one side, and without lateral cohesion: then the transverse motion would be prevented at one side, by the rocks in contact there. If, then, the combined effect of all the resultants were to move any lamina from the fixed rock, that motion would take place; if it were to move any lamina towards the fixed rock, the result might be either the crushing these rocks, or their yielding in some other part to a resultant in the opposite direction; for the resistance of the fixed rocks might modify the applied force, so as to produce intermediate resultants from these rocks.

This case would become modified by lateral cohesion of the lamina as follows: if the sum of the resultants *from* the fixed rocks were greater than *towards* them, all the laminæ, or strata, would move in that direction, unless the general resultant of any part was towards the fixed rocks, and also able to overcome the cohesion of its separating plane, before the force had become great enough to bend the whole, in which case, the lateral cohesion could only effect the line of division; and *vice versa*, if the sum of the resultants *towards* the fixed rocks be greater than *from* them, the mass will be as if solid, until the resultant of some part at the off side be *from* these rocks,

and also able to overcome the lateral cohesion of the longitudinal divisional plane which separates it. In either case, the part divided towards the fixed rocks would either be crushed, and so by its fragments fill up the hollow formed by the bend of the other part, or it would be forced from these rocks at some other point, when the general resultant was in that direction.

In the third case, where the strata acted on are enclosed between rocks above and below, it is obvious that if these rocks be absolutely fixed on both sides, that those acted on by the force, not being permitted to bend as a lamina, or to chip off as a solid mass, will effectually resist the force applied, excepting so far as they may be compressed, and when a certain amount of compression has taken place, there will be equilibrium.

However we may suppose the rocks on one side to be fixed, those on the other being merely held by their own weight, in which case, as soon as the resultant in the upper direction is able to overcome their weight, it will raise the superincumbent rocks. But their weight or reaction will again modify the final effect; for it being resolved into two directions, ($a\,b$) and ($a\,c$,) the component $a\,c$ equiliberates the force applied, producing at the same time a pressure at c downwards, while the component $a\,b$ gives rise to a pressure downwards, at b, and at the same time to a horizontal force, which tends to produce in the further parts of the strata, an action similar to that of the original force.

As a certain amount of original force is spent in overcoming friction, the action or effort must diminish for every successive wave, or bend rapidly. Nevertheless, as we may suppose the friction inconsiderable, as compared with the force applied, there may be found a series of such waves or bends as above. And it may here be mentioned, that, *but for the friction*, the action of the force being continued through the whole length of the strata, one particle communicating it to the next, the first bend would be formed wherever the combined effects of the rigidity of the strata themselves, and the weight of the overlying rocks, which are the resistance to the formation of these bands, were least. The friction causes the first bend to be made near the point of application of the force.

We would remark also, that the effect of the downward pressures at b and c (above) may be similar to that of the pillars which support the roof of a mine; they may cause that part of the lower

rock underneath the centre of the bend, to rise gradually, and fill the hollow, or partially hollow, space formed. And in like manner, the weight of the overlying beds may cause them to fall gradually, and fill in the alternate sinus.

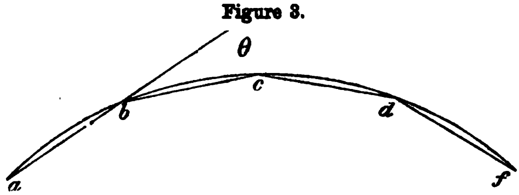
In the preceding remarks we considered the effect of the application of a force to the terminal plane of a thin lamina, supposed slightly bent, and such, that the two parts of the lamina, on either side of the point furthest removed from the direction of the force, were rigid, and were therefore capable of transmitting forces. Thus if two beams, *a b* and *c b*, (fig. 1, page 279,) were resting against each other, at *b*, and that a force (F) acts at *a*, in the direction *a c*. it was merely stated, according to the parallelogram of forces, that the component of F, in the direction of *a b*, with the reaction of the point *c*, in the direction of *c b*, gives rise to an upward force at *b*, varying according to the position of the opposing plane, to which its direction must be perpendicular.

If in such a case *c* be supposed fixed, and *c b* incompressible, the point *b* is constrained to move in a circle whose centre is *c*, and whose radius is *c b*; and the resultant upward force in that case perpendicular to *c b*, will be a maximum, when the angle *a b c* is a right angle.

The hypothesis of *rigidity* being, however, scarcely applicable to rock strata, let us consider the subject in a more legitimate point of view.

For this purpose, let us imagine a number of bars of equal length, capable of resisting compression, and having their ends in contact with a fixed curve, which, for simplicity, we shall consider a circle.

Figure 3.



A force, F, being applied at *a*, in the direction *a b*, and (*f*) being a fixed point, it is required to find the pressure against the fixed curve, and also against the point, *f*, (*friction not being taken into account.*) In this case the force F is resolved at *b*, into a normal force, $= 2\ \mathrm{F}\ \sin.\ \frac{\theta}{2}$ (θ being the external angle between two con-

secutive bars,) and a force, $=$ F in the direction of $b\,c$, which again is of course similarly resolved into a normal force at $c = 2$ F sin. $\frac{\theta}{2}$ and a force $=$ F along $c\,d$. The force F, applied at b, in the direction of $a\,b$, gives rise, therefore, to a pressure, $= 2$ F sin. $\frac{\theta}{2}$ against the curve at all the points of contact, and to a reaction at f, equal to itself; all the bars being subjected to a compressive force $=$ F also.

Further, if (α) denote the inclination of any side to the axis of (x) and (a) the inclination of $(a\,b)$ to the same, since the principle of the funicular polygon (that all the forces transferred to any point form an equilibrium) holds here, we have, calling as above, the compressing force along any side F, and the normal pressure, N,

$$- \text{F cos. } \alpha_n = - \text{F cos. } a + \lessgtr \text{N sin.} \left(a + \frac{\theta}{2} \right)$$

Supposing now the number of these bars to become infinite, we shall have an incompressible ring in contact with the concave side, so to speak, of a fixed circle, and it is required to find the pressure against the curve resulting from the application of a force F, at one end of the ring, inthe direction of the tangent at the point of application.

The compressive force is then every where the same, and equal to F by last proposition; but the normal force, or the reaction of the curve at any point, is infinitely smaller than the compression. This appears from the equation $\text{N} = 2$ F sin. $\frac{\theta}{2}$; because θ being $=$ O, N $=$ O. Wherefore, in order to compare the normal force with the force applied, we must take it not for a mathematical point, but for some definite portion of the curve.

But before proceeding to estimate the reaction, let us advance to a case somewhat more general, and consider a fixed curve of any form of single curvature; and showing that the compressive force remains the same for all parts of the curve, proceed to consider the amount of the normal force or reaction in this general case.

Considering, then, three consecutive points on the curve, or two consecutive elements, let the force F act in one, and the force F′ in the other. As the three points are on the circumference of the osculating circle, and as we have proved that in the case of a circle, the forces acting in the two consecutive elements are equal, it follows that they are also equal in this case, and therefore, by proceeding from element to element, it appears that the compressive force is the same throughout the curve.*

* In order to be satisfied of this, let us apply to the case in question the following proposition: If any three forces form equilibrium at any point, the difference between any two is to the third, as the sin. of ½ diff. of the angles that the latter makes with the two former, is to the sin. ½ sum of same angles. We have therefore the difference between the two forces compressing each element—

: The reaction at the intermediate point.

: : Sin. ½ difference of the angles, which the tangent makes with the consecutive elements.

: Sin. ½ angle contained by them.

The difference between the forces acting in each element, is, therefore, infinitely less than

Having now established the equality of the compressive force for all parts of the curve, we proceed to estimate the amount of pressure against it, or the reaction.

In the case of an equilateral polygon, we have shown that

$$-F \cos. a_n = -F \cos. a + \lesssim N \sin. \left(a + \frac{\theta}{2}\right)$$

when

$F =$ force applied, which is $=$ compression.
$a\ a\ a_1\ a_2 \ldots\ a_n$ inclination of sides to axis of x.
$N =$ normal pressure.
$\theta =$ External angle between two consecutive sides.
$\lesssim =$ sum for all the (n) points of reaction.

If, then, the polygon have an infinite number of sides, or, in other words, becomes a curve, we shall have

$$-F \cos. a = -F \cos. a + \int N \sin. a\, d s,$$

N being supposed constant for the element $d s$, and to represent a pressure $=$ to that at $d s$, applied along a unit of length, a being the angle made by the tangent at the first point of any element, $d s$, with the axis of x, and a the inclination to the same axis of the force F, which is applied tangentically at the beginning of the curve, θ of course having become equal to O. Now differentiating, we have $F\, d a = N\, d s$: but $d a = \frac{d s}{\rho}$; therefore $\frac{F\, d s}{\rho} = N\, d s$, or $N = \frac{F}{\rho}$; that is, the normal pressure exerted against the curve at any point is proportional to the force applied directly, and inversely, as the radius of curvature at that point.

To estimate the amount of this force, we shall return to the equation $N\, d s = F\, d a$, and by integrating we obtain

$$\int N\, d s \text{ (or total pressure)} = F \int d a = F a'$$

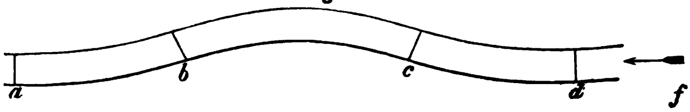
when a' is the angle between tangents at first and last points.

Let us now proceed to apply this proposition to determine what will be the effect on bedded rocks, of a pressure acting on them in the direction of their planes of bedding. We shall take for granted that the planes acted upon are slightly bent, that is, not in the same plane as force applied, mathematically; for there are many causes tending to raise and depress the beds, even if originally deposited exactly in planes; besides, the very action of lateral force, would, by crushing some beds, tend to derange the perfect regularity of others. And we shall also consider the fixed curve of our proposition as represented by underlying or overlying rocks. We shall then

the pressure against the curve or the reaction; but we have previously shown, that this pressure required to act over a definite portion of the curve to be itself estimated, being infinitely smaller than the compression: it follows, therefore, that even for a definite portion of the curve, the difference between the compressive force at its extremities is infinitely small.

have as in figure 3, confining ourselves at first to a single bed, a

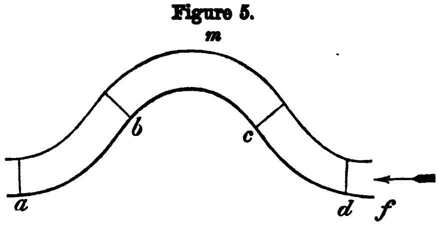
Figure 4.



force acting at d in the direction of $f\,d$, on the bed or stratum $f\,d\,c\,b\,a$, to find the different pressures resulting therefrom, first disregarding friction. We shall here premise that it is necessary to consider the stratum as first curved downwards, then at a certain point c without any curvature, and after that curving upwards, as far as the point b, when the curvature again changes, and finally becoming at (a) again horizontal; this is necessary to avoid any angular point, and is obviously the most likely form for the stratum to assume.

There is, then, evidently by our proposition a normal pressure downwards from d to c; upwards from c to b; and downwards from b to a. Supposing this pressure to be strong enough to overcome to a certain extent the resistance of the adjacent masses, the stratum will tend to become more curved, its next stage being, as it were, represented by fig. 5.

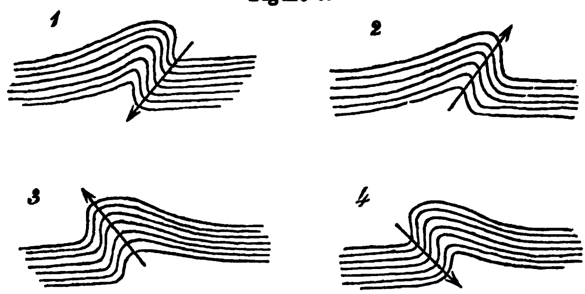
Figure 5.



Proceeding to consider the form which the stratum may assume, should the adjacent beds give way to the pressure exerted upon them, let us suppose these beds above and below to have been originally conformable with that acted upon; it is clear, then, that the resistance to the pressure exerted vertically upwards, will be much greater than that at the sides (so to speak) of the bend, (the overlying masses being considered as very great compared with that of the stratum itself.) We may, therefore, divide the curve into four parts, in any one of which, if the yielding take place, the

final position of the stratum will be different, viz.—from *d* to *c*; from *c* to *m*; from *m* to *b*; from *b* to *a*; these different positions being represented as follows:—

Figure 6.



Theoretically speaking, the friction will, by diminishing the compressive force, tend also to diminish the normal pressure, which will be, therefore, greatest near the source of pressure. In a single bend, the yielding would, according to this, be most likely to take place as in No. 1, least likely as in No. 4. But the varying nature of the stratum acted upon, as well as of the contiguous strata, would be much more likely to determine the point of yielding than any change in the pressure produced by friction.

Having thus attempted to exhibit the effects in the case of a single bend, let us consider the case when more than one curve may have been formed:

In order to do this, it is only necesssary to consider the compressive force at (*a*) as an originally applied force, producing a second bend in the same way as the first was formed, and so on for a third, fourth, &c. &c.

Disregarding friction, it is obvious that the compressing force will continue uniform throughout the series of curves, which will therefore extend, until some change in the strata, independent of this force, impedes their formation. When friction is taken into account, it will, of course, diminish the compressive force, as we proceed from the extremity at which it is applied, and therefore, the magnitude of the curvatures or contortions; but it is thought, that if a number of conformable beds be simultaneously acted upon, the friction *against* the upper surface of one reacting as an additional force on the

lower surface of the one above, in the opposite direction, all the friction may be disregarded, except that at the lower surface of the lowest, and the upper surface of the highest bed; and that although the force F will be diminished in a degree by this friction, at each successive bend, yet we may still presume a number of bends to be formed, decreasing in size as the compressive force decreases.

Again, if a yielding should take place at any curve, the force may be transmitted through the medium of the crushed rocks; and we may thus have, under the influence of a constant pressure, any number of bends or contortions, fractured or otherwise, produced in the same stratum, or series of strata.

In the case where there is no superincumbent rock, the normal pressure downwards may be supposed counteracted by the rocks below, as before; and that upwards to be resisted by the weight of the mass of the stratum or strata acted upon, which resolved in the direction of the normal to the bend, which the strata have assumed, may, although not accurately equal to it, counteract the normal pressure, the rigidity of the strata maintaining the equilibrium.

As the force required to elevate the curve or bend of the strata, diminishes as the curvature increases, it appears, that once the strata have begun to assume the curvilinear shape, they will, if the pressure be constant, continue bending, until fracture takes place, and that no other bend can be formed until this result has happened. If, however, we consider, that the friction which impedes the transmission of the applied force to affect the further parts of the strata is, diminished, as soon as the first portion of the strata where it acts has begun to bend upwards, it will be seen that at that moment, a second or a third bend may begin to be formed; that bend, however, which under the circumstances is most easily formed, will proceed to its yielding point before the others can be developed. In this way a series of broken curves may be formed.

Lastly: if a considerable thickness of strata be acted upon, or if the influence of the pressure extend only to a certain distance from its source, we may have a number of regular unbroken undulations, without any superincumbent rocks.